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ANIMATED MAPS OF TROPICAL STORMS

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Richard Groop
Major professor

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ANIMATED MAPS OF TROPICAL STORMS

By

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ABSTRACT

ANIMATED MAPS OF TROPICAL STORMS

By

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Geographic objects moving through space and time pose a cartographic problem that is difficult to solve without the aid of animation. This thesis uses several relatively inexpensive software packages and cartographic techniques to animate the phenomena. Data on tropical storm movement in the North Atlantic Basin over a 50 year period are used for these illustrations. Results indicate that none of the software solutions tested here are ideally suited for these kinds of animations; however, showing movement over space through time is possible and the resulting maps and animations are intriguing.

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Static views of the Earth are useful for descriptive purposes, but true understanding of movement and change is necessary for analysis."

Hardwick and Holtgrieve, 1990

CHAPTER ONE
HURRICANES AND ANIMATION

Through Time and Space: Movement in Geography

Movement is an essential part of geography. Bunge (1966, p. 112) states that "in explaining how an object acquires its location it is difficult to avoid the notion of movement. Even such 'static' features as mountains and seacoasts are explained in terms of movements taking place over long periods." Bunge also notes (p. 112) that "it is the geographer Ullman who has struck upon the essential unity of spatial movement theories with his implicit question, 'What makes objects move over the earth's surface?' It can be argued that Ullman's question encompasses all geographic theory..."

Geographers study the earth's systems. These include the interactions within, among and between people, plants, animals, and the physical earth. "Elements of a system are recognizable entities with measurable attributes" (Abler, Marcus and Olson 1992, p. 234). Within a system connections "are the pathways by which energy, mass, people, goods, or information pass from one element to another. Taken together, the elements and their connections exist in a state that may change through time and that produces a mappable geographic pattern" (Abler, Marcus and Olson 1992, pp. 234-5).

Through time, systems and patterns change. "Geographers begin with static descriptions, but their explanations inevitably incorporate dynamic processes characterized by change" (Abler, Marcus and Olson 1992, p. 234). Consequently, geographers are faced with the difficulty of representing spatial and temporal change within these systems.

Movement, as described by Hardwick and Holtgrieve (1990, p. 310), is "transportation or communication over space and time." They describe four major forms of movement; the movement of people (migration), information (communication), ideas (diffusion), and goods (trade or transportation). These same concepts are discussed by Lowe and Moryadas (1975). However, these studies are limited to human-environment interaction as the basis of movement; they do not address movement of or within physical systems and thus ignore the concepts of energy and mass.

Tropical Storms

Tropical cyclones are an example of a physical phenomenon that incorporates movement of energy and mass through space and time.

In the North Atlantic basin and the eastern Pacific Ocean, strong tropical cyclones are referred to as hurricanes. These same storms in Australia and India are called cyclones, in the western north Pacific, typhoons.

Hurricanes form from tropical storms, usually originating between 5 and 20 degrees of latitude. They are violent storms with wind speeds in excess of 74 miles per hour. On rare occasion, wind speeds may even reach speeds in excess of 180 miles per hour. Hurricanes are rated on a intensity scale called the Saffir-Simpson scale of intensity. The scale uses ranges of central pressure, wind speed and storm surge to designate storms into five categories of hurricane, from category 1, a minimal hurricane, to category 5, a catastrophic hurricane (Table 1).

Table 1 Saffir-Simpson scale of hurricane intensity

Category	Central Pressure (mb)	Winds (mi/hr)	Storm Surge (ft)	Damage
1	> 980	74-95	4-5	Minimal
2	965-979	96-110	6-8	Moderate
3	945-964	111-130	9-12	Extensive
4	920-944	131-155	13-18	Extreme
5	< 920	>155	>18	Catastrophic

During the peak of the Atlantic Basin hurricane season (late August to early October), hurricanes often form as tropical depressions off the coast of Africa and travel westward toward the Caribbean islands. Hurricanes can also form in the Caribbean Sea and travel north into the Gulf of Mexico. Storms that originate in the eastern Atlantic tend to either travel westward through the Caribbean Sea into the Gulf of Mexico or swing north as they approach the Caribbean Islands and move northward along the coast, finally swinging back towards Europe (Figure 1). Not all hurricanes follow these paths; hurricanes are well-known for their erratic path behavior.

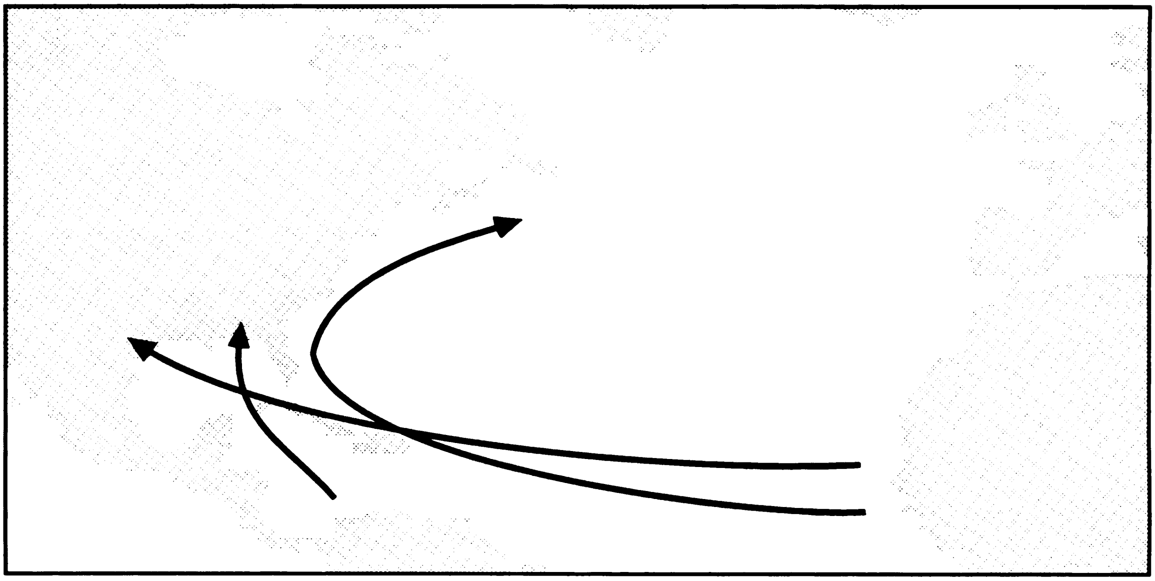

Figure 1 Three general paths of hurricane movement in the North Atlantic

In addition to variations in storm path, there are also variations in the number of storms that form each year, the strength of these storms, and their temporal patterns. An average of between nine and ten tropical storms form each year in the North Atlantic basin and on average about six of these storms develop into full-fledged hurricanes. From the year 1944 until the year 1993, the maximum number of tropical storms, including hurricanes, that formed in any one year was eighteen and the minimum was four. For this same time period, the maximum number of tropical storms that reached hurricane status was twelve and the minimum was two. Although the database that will be used for this project extended back to the year 1886, it is recommended that data before the year 1944 not be relied on since it was not until this year that reconnaissance aircraft were first used to help track storms (Appendix A). Tropical Storms are now tracked by satellite. Measurements of wind speed and pressure are either measured directly, interpolated or estimated from satellite imagery.

Because hurricanes have such spatial and temporal variation, it would be both interesting and useful to have a visualization tool that allowed for the portrayal of their many characteristics simultaneously to achieve a better understanding of them. As noted by MacEachren (Abler, Marcus and Olson 1992, p. 101) "Recent interest in scientific visualization has emphasized development of new and more powerful visualization tools such as computer animation and three dimensional modeling." Computer animation as a visualization tool is here evaluated as a technique for better understanding phenomena that move through space and time.

Animation: A Method of Display

Because of limitations imposed by traditional cartographic techniques, the convention in cartography has been the production of static maps (Campbell and Egbert 1990). "Maps ...have long been used to depict change. With maps, there are two traditional strategies: single static maps that depict limited aspects of change in or across space and multiple static maps that can be visually compared" (Abler, Marcus and Olson 1992, p. 120). Single static maps depicting change can be divided into two groups (Figure 2). The first group

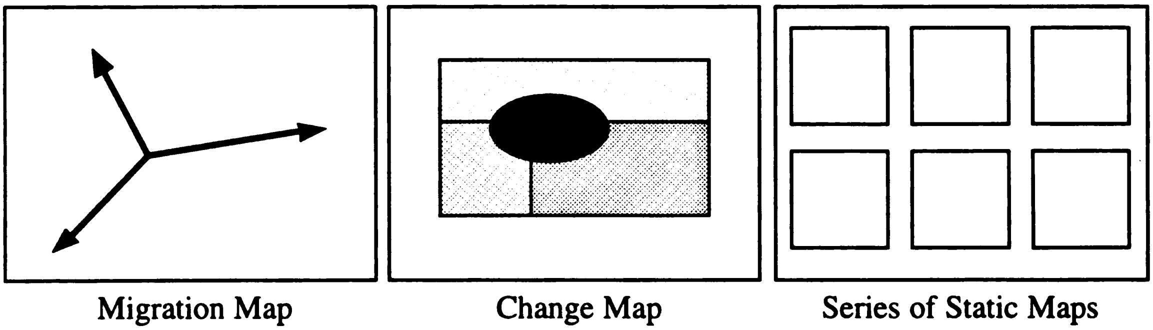

Figure 2 Different types of static maps

includes maps that represent movement between places, such as maps of migration or trade. The second group includes maps that display change over time in a fixed place, such as a map of population growth and decline (Abler, Marcus and Olson 1992). A third way that is often used to depict change (Figure 2), uses a series of static maps. This method is often used when showing phenomena through time since each frame can be a specific point in time. This method most closely resembles the animated map, however the map reader is left to interpolate what happens between each image. Thrower in his article "Animated Cartography in the United States" discusses the limitations of static maps for showing change:

> It is widely recognized that a single illustration, however, good in itself, has definite limitations for indicating change through a considerable period of time. For showing progressive development in the physical and cultural landscape it has been customary to use maps or diagrams in series. ... But, valuable as these maps in series may be for showing changing phenomena, they too have limitations. This is so because, while in reality changes proceed more or less continuously, the maps in a series show only instantaneous cross sections of an area, or snapshots. ...However, by the use of animated cartography we can bridge the gap and give an impression of continuous change (Thrower 1961, pp. 20-1).

It is this impression of continuous change, of movement, that makes animation such a powerful tool in the visualization of geographic phenomena. We need animation "to cope with the amount and complexity of information. Our curiosity inspires us to see what stories these huge banks of data have to tell" (Dorling 1992, p. 225). In order to satisfy that curiosity we must be able to see, or visualize, those phenomena and cartographic animation allows us to do that.

One appealing aspect of animation in cartography is "the ability to show change through time in a way that is more powerful than the creation of a series of static maps" (Moellering 1980, p. 67). While "it may be true that impressions of animated images seldom persist if they stand alone, ...with timely reinforcement an animated map is one of the best ways to communicate ideas about spatial relationships and their changes through time" (Gersmehl 1990, p. 3).

Problem Statement

This thesis will use three animation software packages that employ different visualization and cartographic techniques to produce animations of tropical cyclone data from the North Atlantic basin. The animation packages are Macromedia Director, Spyglass Transform, and Apple HyperCard, all operating on a Macintosh computer. Each package approaches animation in a unique way, and each has different strengths and weaknesses. However, all three have several attributes in common. They are all relatively inexpensive, capable of producing animation, not extraordinarily difficult to operate, commonly used, and they all run on a desktop computer.

Macromedia Director is primarily an animation package, an authoring tool for multimedia productions. It is the most expensive, as well as the most complex, of the three software packages. Spyglass Transform, on the other hand, is used more often as a data visualization tool. It incorporates animation only as an small component of a larger visualization package. HyperCard, which is produced by Apple Computer, is the least expensive of the three packages. It is a tool that can be used to construct small independent programs or stacks that link information together. In the past, HyperCard has been a popular tool for creating simple animations and multimedia productions.

Each of the packages was used to create animations of tropical storm and hurricane data. The animations were created with the intention of using the strengths and capabilities of each program to help in the visualization of tropical storm and hurricane data.

This thesis will examine the advantages and disadvantages of these three software packages in illustrating, through animation, a geographical phenomena that moves through space and time. Discussion of the results will include both a subjective evaluation by the author, as well as objective comments of independent observers.

CHAPTER TWO

ANIMATING TROPICAL STORMS

Tropical Storm Data

Hurricane data were acquired via the internet from Colorado State University. However, as stated in the documentation that accompanies the file, the data are "maintained by the forecasters and researchers at the National Hurricane Center in [Coral Beach], Florida." and "permission to make free access of this data and documentation [is] provided by Dr. Robert Sheets - director of NHC and by Mr. Neal Lott of the National Climatic Data Center in Ashville, NC." A copy of this documentation, which includes descriptions of the data format is included in Appendix A.

The file itself includes a large amount of information. For every known tropical storm in the North Atlantic Basin, from 1886 to 1993, the following information are recorded:

- Year, month, and day the storm was first recorded
- Duration of the storm in days
- Storm number for that year (including subtropical storms)
- Storm number since the beginning of record (1886)
- Name of the storm (if available)
- Maximum intensity of the storm (hurricane, tropical, subtropical)
- Whether or not the storm made US landfall as a tropical storm or hurricane
- Highest category (Saffir-Simpson scale) of the storm, at landfall, if the storm made landfall
- State or region of US landfall and the Saffir-Simpson category at that landfall

The following information is included at six hour intervals (00Z, 06Z, 12Z, 18Z):

- Month and day
- Storm stage
- Latitude and longitude of the storm
- Maximum sustained surface wind speed in knots
- Central surface pressure in mb (if available)

A short program was written in Basic to sort through and organize the data into a format which could be read into Microsoft Excel spreadsheet and into a Microsoft FoxPro relational database where more processing took place.

There were three types of data lines in the original file (see Appendix A for a full description). Line types “A” and “C” contained summary information about each storm and line type “B” contained the detailed locational and strength information at six hour intervals for each day of the storm. The relational database made it possible to connect these two types of information with a common variable and to select records from either file. For example, one could ask for the name and year of any storm whose maximum winds were greater than 135 knots, a class five hurricane. The program would then return a list of storms and their years which met the criteria.

The base map that was used in each of the animations, for location reference, was a cylindrical equidistant projection (Figure 3). The reason this map projection was chosen is that the latitude and longitude lines form perfect squares which makes it easy to plot data using an x,y coordinate system. Although there are some distortions in higher latitudes (east/west distances are more exaggerated nearer the pole), for the purposes of this project, the base map provided a useful reference for the data.

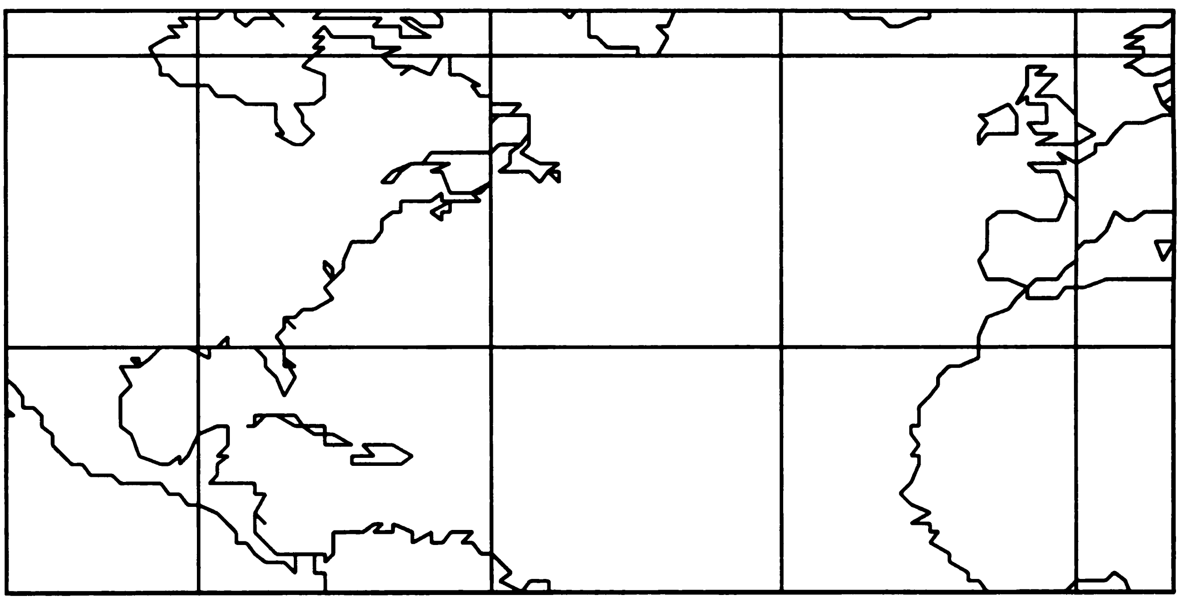

Figure 3 Base map of the North Atlantic Region frequented by tropical storms.

Software Packages

Transform

Transform is a program created by Spyglass, Inc. that works as a tool for "analyzing matrix and image data" (Spyglass 1993). Data can be entered either directly in matrix form or in column form which Transform then modifies in order create a matrix. With this matrix of data the user can then quickly and easily generate images.

Transform works by first creating a matrix of numbers and then assigning a color to each cell based on the data value. "Data for Spyglass Transform usually consists of two independent variables and one dependent variable arranged as a 2-D array of numbers." "Color raster imaging, along with a spreadsheet-like display of the numbers, surface plots, vector plots, contour plots, and interactive line graphing, presents a powerful list of tools..." available to the user (Spyglass, 1993, p. 3).

In the case of the images created for this project, columns of numbers (latitude, longitude and wind speed) were imported and modified to create a matrix of longitude by latitude in 0.5 degree increments with wind speed, in knots, as the value within each cell. Figure 4 shows a 0.5 by 0.5 degree grid superimposed over Florida and the Gulf Coast to Louisiana.

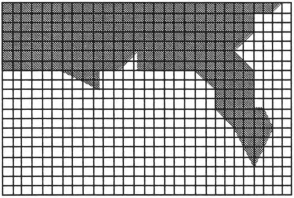

Figure 4 A one half degree grid superimposed over a map Florida and the Eastern Gulf Coast

Next the data set was smoothed using the "smooth" command which creates a new data set. Smoothing is accomplished by averaging every point with its eight surrounding neighbors for a user specified number of iterations (Spyglass 1993).

Once the new smoothed data set has been created, an image can be generated using either the "Generate Image" command or the "Interpolate Image" command. When the image is displayed with one pixel representing each value in the matrix, the generated image looks smooth and one cannot see individual cells. However, if the "zoom" is set to greater then one, each value is represented by a group or block of pixels. This "chunky" appearance can be avoided by interpolating the image, which smoothes the transition between blocks of pixels representing different data values.

Once an image has been generated, there are a variety of tools within Transform to help fashion the image. The size of the image can be set by either selecting the size of the image in pixels or by selecting the "zoom" factor. When the "zoom" is equal to one, then one pixel represents each data cell in the matrix. When the zoom for X is equal to the zoom for Y then the blocks of pixels representing each data block form squares. An "Axes

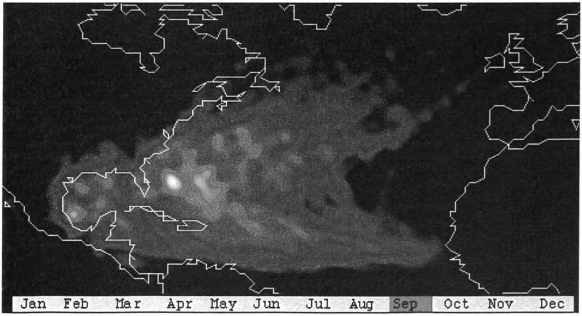

Figure 5 One frame of the Transform animation

tool" allows the creation and display of text along the axes and a title for the image. There is a long list of different color tables that allows changing the colors assigned to each value. It is also possible to import a custom color table. There is also a "fiddle" tool that allows setting of colors to white, or to compress and shift the color range and rotate the colors. Once the image has been created, an overlay can be added to enhance, annotate, reference or add new pieces of information to the existing image. In the case of the images for this project a base map was overlaid for reference purposes.

Once a series of images have been created, Spyglass View can be used to create animations from these images. Each image becomes a frame within the movie and by displaying these frames in rapid succession the illusion of movement is created.

A sequence of procedures was followed to create a series of images that could be "played" to create an animation (Appendix C). In each of the images created, latitude and longitude were used as the X and Y coordinates and wind speed as the Z value. The data were aggregated by compressing a fifty year time span into one year. For example, for each image in the first animation I selected all the storm positions, and their corresponding wind speeds, that fell within the month of September for every year from 1944 to 1993. Where a given pair of x,y coordinates were associated with more than one wind speed value (i.e. multiple storms passed over the same coordinates), the wind speeds were added together. The values in the resulting matrix represent an index of storm severity and frequency at different locations.

To test this procedure, data were aggregated by month over the fifty year period for the first animation. A new image was created for each of the twelve months of the year using only those storms which reached hurricane strength. This same process was followed again in creating the second animation, but this time using weekly data and all storm types. These initial animations were not acceptable because of "choppiness" in the display and because of color allocation problems. Adjustments in data sequence and minimum and maximum color assignments and interpolation were performed and a more acceptable set of images were created for use in the animation.

In this re-creation of the animation I employed a moving average to smooth the frequency data. The moving average used a four week time span in the following way: weeks 23, 24, 25, & 26 were averaged for frame F1; weeks 24, 25, 26, & 27 were averaged for frame F2; weeks 25, 26, 27, & 28 were averaged for frame F3 and so forth. The result was a 52 frame year each containing about one month worth of data. This end product was produced as "Animation 1:Transform."

HyperCard

HyperCard is a card-based system that works rather like a stack of index cards. Stacks, cards, buttons, and fields can be created to call other stacks, cards, buttons and fields, or even other programs. For this reason, HyperCard is very good at setting up simple hyperlinks, but for animation it is somewhat crude.

Although HyperCard does have a "foreground/background" set-up feature, for purposes of animation, the program works similar to a flip-book -- movement is shown by "flipping" through a series of cards in rapid succession. This works well if the images are already constructed and can be imported in from another program. However, because HyperCard is monochromatic, the images are black and white, regardless of the colors in the original images. The program is not capable of moving objects within HyperCard based on external data; objects can only be moved on the screen by "flipping" already-created images. The foreground / background option allows one to place objects that will be the same from frame to frame in the background so that it does not have to be placed on each card. This also saves program speed and memory space. See Appendix B for detailed instructions for creating an animated HyperCard stack.

HyperCard Animation 1: Hurricane Debbie, 1969

After searching the database for years when there were many strong storms, two years, 1969 and 1992, were extracted. From these years seven storms, five from 1969 (from a total of 18), and two from 1992 (from a total of 7), were used. I extracted the latitude, longitude and wind speed for these storms and transferred them into "Transform." Transform was used because it has a feature that allows equal spacing on the X and Y axes and because the base map was formatted for this program. However, any program with plotting capabilities could have been used.

After the data had been converted, I plotted the map and adjusted the colors so that values appeared as gray tones on a white background.

Hurricane Debbie was selected for the first animation because it was a fairly simple and common storm track (coming off the coast of Africa, westward through the tropics, swinging north along the west side of the Atlantic, then east as it reached the northern latitudes). The image of the storm track was processed in Freehand by placing the image in a background layer and drawing a line that represented the storm track with a node at each of the storm positions that had been plotted in Transform. I also drew a line around the border of the map, so that I could more easily and accurately position the storm track over the map in HyperCard.

In HyperCard, I set up a stack with a few buttons, a title, and a map in the background. I made thirteen copies of the card and starting with the last one, I pasted on the storm track of Hurricane Debbie. I then pasted this information to the appropriate card in the stack, working backwards with the first card showing no track at all. I then scripted the cards in order with a one-second delay between each card. The resulting animation gives the impression that the storm track grew with each passing day. Although this animation was crude and took a lengthy time to construct, it did show the storm track as it moved across the Atlantic (Figure 6). See Appendix B for more detailed instructions on the creation of these HyperCard animations.

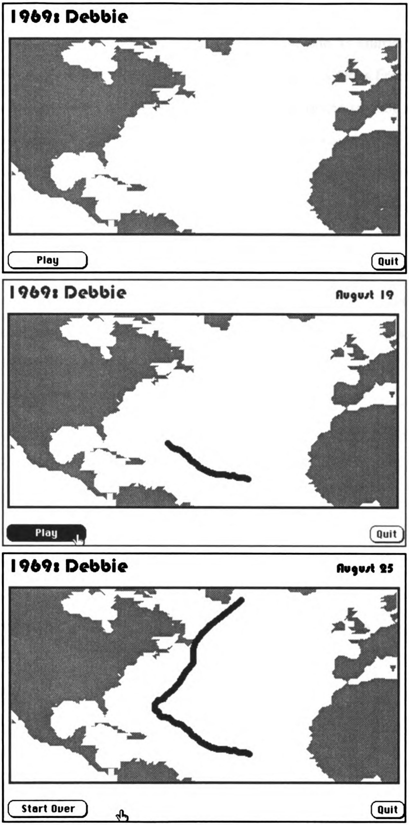

Figure 6 Three frames from Hurricane Debbie animation

HyperCard Animation 2: Tropical Storm Anna, 1969

This HyperCard animation was created much like the one for Hurricane Debbie. The data points were plotted in Transform and then imported into Aldus Freehand. However, instead of drawing a line that connected the points, a hurricane symbol was created and positioned at each of the plotted locations. The symbol was then "colored" in patterns of gray to represent the wind speed at each location. Tropical Storm Anna last for a duration 12 days, with location information every six hours, providing 46 different points that needed to be positioned, "colored," copied and pasted into HyperCard, each on a separate card. As with the first animation, a "play" button was scripted to display the data in order with a one second delay between cards. This gave the impression of the storm moving across the ocean, changing from light to dark as the storm intensity changed (Figure 7).

HyperCard Animation 3: 1992 Hurricane Season

The last of the HyperCard animations shows an entire hurricane season as it progresses from the middle of August through the end of October, with six storms. Again the images were created much like the first two: data points were plotted and imported into Freehand, lines were drawn connecting the points of the storms together into one day segments, and segments were "colored" in gray patterns to represent the tail of the storm, which got lighter with each passing day. The current day segment was black. These line segments were cut and pasted into HyperCard so that the storms happened at the correct temporal position. The first storm completed its path in the beginning of the season, followed by a period of no storm activity, followed by an explosion of storm activity as four storms moved about in different parts of the ocean, then another break in the storm activity, and finally, one last storm of the season. Although this took a large amount of copying and pasting to complete the animation, the result showed how the storms moved in relation to each other throughout the storm season (Figure 8).

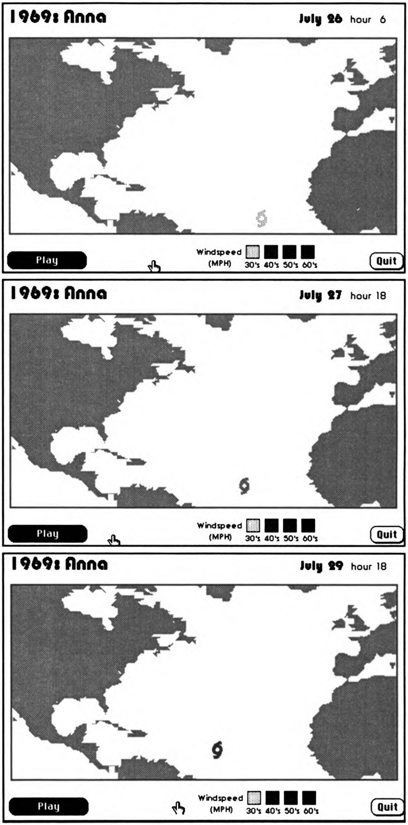

Figure 7 Three frames from Tropical Storm Anna animation

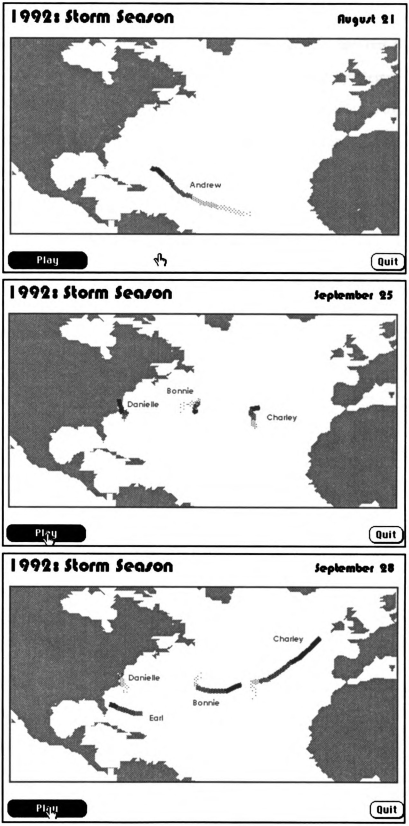

Figure 8 Three frames from 1992 Storm Season animation

Director

Macromedia Director is an authoring tool for multimedia productions (MacroMedia 1994). Director uses the "Stage and Play" metaphor as described by Gersmehl (1990, p. 6). The first step is to design the "stage." I enlarged the size of the map so that it filled the stage area and placed it on the top portion of the screen. The legend was later placed on the bottom portion of the stage.

When creating animations in a "scripting" environment like the one in Director, it is easiest to progress slowly through the process, scripting one element at a time, adjusting it until it works, and then moving on to the next step. This allows debugging the animation as it is created. If all the scripts were written at once and not checked, the program may not work and finding the problem in the animation could be difficult.

The first step was to import data from outside text files into Director and use these data to move a circle around on the stage. Once this was accomplished I could then create separate files for longitude and latitude, with numbers that could be read by Director, and direct the symbol where to move on top of the map. However, since Director has its own coordinate system, I needed to transform the numbers to correspond to the screen coordinate system.

Once I had the symbol moving about the stage as I wanted, I needed to add a third dimension, the wind speed. This Z value was assigned a color and size; this allowed the symbol to move across the stage changing size and color proportional to wind speed and strength.

I also wanted the user to be able to see, in number form, what the latitude, longitude and wind speed were and also to see the category, date, and time. These variables were written to text boxes on the screen and integrated with the moving symbols.

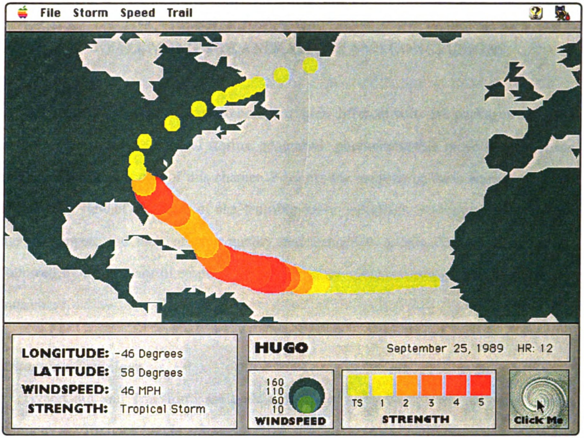

Figure 9 A screen capture from the Director animation

As additional storms were added, custom menus were created that gave the user a choice of storms, a choice of animation speed, and a choice of storm trail or no storm trail behind it (Figure 9). See Appendix D for detailed instructions on data preparation and operation of Director.

CHAPTER THREE

EVALUATING THE ANIMATIONS AND CONCLUSIONS

The intent of this project was to compare three different software packages based on their ability to animate tropical storms, geographic phenomena that move through space and time. In the first part of this chapter, I discuss the analysis of these animations from the point of view of cost, ease of use, learning curve, animation technique, ability to handle data input, and their graphic quality and animation quality. This section will be followed by a summary of responses given by other observers of the animations during interviews.

Animation Technique

HyperCard and Transform are both card-based animations, what Gersmehl (1990) refers to as "flipbook" style animation. Gersmehl (p. 6) effectively sums up my experience of using this type of animation, stating:

> "...the flipbook technique is labor-intensive; each scene must be drawn (or at least assembled) in its entirety, and a convincing illusion of smooth motion usually requires about a dozen scenes per second. Image cloning and electronic modification can lessen this burden considerably, but with today's equipment the list of options is large, and the flipbook metaphor is seldom the easiest way to add motion to a map."

Macromedia Director on the other hand uses what Gersmehl terms a "stage and play" form of animation. In this type of animation the 'stage' usually has a backdrop that remains stationary throughout the animated sequence and the actors that move about, sometimes changing form and color, in front of this backdrop. In Director, the stage is the screen, and cast members are placed on the screen either in the score or as directed by a series of scripts. Images of cast members that appear on the screen are referred to as sprites. Sprites in Director, not to be confused with Gersmehl's sprites, can move about the screen, changing color, size, and any number of other attributes. This type of animation allows for much more complex animations that can be easily adjusted by changing either the cast member or script for different effects. Thus from the point of view of animation ability, the technique utilized by Director is far more advanced than that utilized by the other two programs.

Data Handling

Although Spyglass Transform technically creates a card-based form of animation, the images for these animations are easily designed by manipulating a matrix of numbers and applying colors based on the numbers in each cell. Although each frame of the animation must be designed separately, once a desired format is established, creating each frame goes quickly. However, as with all card-based animations, making changes, regardless of how small, is a time consuming process; each image must be opened, altered and re-saved. The Transform animation designed for this project contained fifty-two separate images.

Although HyperCard can keep track of a large amount of data, it does not seem to allow for importing data from an external source; nor does it allow objects to be moved around based on data within the program. These limitations force the animation designer to create separate still images and manually move them around on each card to create the illusion of movement.

Director does allow for the import and export of data and allows objects to be moved and changed based on this data. For my Director animation, this meant that once one storm had been scripted, new storms could be added just by creating new text files for the program to read. And since the size, color and position of objects are designated within the script, changes can easily be made by adjusting a few line of the script.

Thus, from a data handling point of view, Transform's abilities are more advanced then the abilities of the other two. However Director, with the use of its scripting language Lingo, does employ some data handling abilities.

Graphic Quality

Of the three programs that I used, HyperCard's graphics were the most unrefined. Since Apple has not yet integrated color into this program, all the stacks created with HyperCard are in black and white. Even shades of gray are simulated with a coarse pattern of black dots.

The other two programs both fully integrate color, which allows for more dramatic visual effects. The animation in Transform is definitely less complicated than that of Director, however the ability to easily generate new images and quickly change between more than a dozen built-in color tables, makes Transform more flexible in a graphic sense.

The Learning Curve and Ease of Use

Transform was the easiest of the three software packages to learn. The manuals are well-written, and the program is quite intuitive. Although the programs uses matrix data, column data are easily transformed and configured with user-defined specifications. The user defines these specifications by answering a series of questions with answers in the form of check boxes, pull-down menus and "fill-in-the-blanks." In a matter of less then fifteen minutes one can create a striking first image.

HyperCard was more difficult to learn. With a brief pass through the tutorials, one could make simple hyperlinked stacks, using predefined clip art, buttons and a little imagination. The manuals were fairly informative and easy to use, and HyperCard's scripting language, HyperTalk, was easy enough to learn if one already knew the basics of how programming languages work. There is also a separate 'Script Language Guide' that deals specifically with the more complex concepts of HyperTalk. Since the scripting I needed to use to play my animations was very basic, it was reasonably easy to learn the necessary HyperTalk commands.

The most difficult program to master was Macromedia Director. With its large number of options and capabilities, Director is the most complex of the three programs.

However, once one grasps the overall design of the process, one can create some interesting animations. Although the manuals were fairly well laid out and basics about the program were clearly described, I found that descriptions of many of the Lingo (Directors scripting language) commands were confusing and that, occasionally, even the sample scripts did not work.

Summary

In summary, each of the programs has its own strengths and weaknesses that are a combination of the topics discussed above. In Table 2 I have summarized my evaluations for each of the programs.

Table 2 Summary of author's evaluation

	Director	Transform	HyperCard
Graphic Quality	very good	excellent	poor
Ease of Use	difficult	easy	moderate
Data Handling	fair	excellent	poor
Animation Technique	excellent	crude	crude
Cost *	$800	$399	$99
Overall Evaluation	recommend	recommend	not recommend

* Approximate Retail Price: November, 1995

Director has its strength in its multitude of options and its powerful features which allow the user to design many different types of animations that are visually appealing. However these strengths come at a price, both monetary and in learning time.

Transform takes very little time to learn. It is able to handle large data sets and to quickly transform them into an image with stunning colors. Its one major limitation is that the animation is card-based; to change a small part of the display, one has to change it on each individual frame, a time-consuming process for the perfectionist.

HyperCard's main attraction is its lower price. Although it is fairly easy to create hyperlinks between different cards or stacks, HyperCard's limitation of black-and-white and its inability to allow objects to be moved around based on a coordinate system, make it difficult to create animations that effectively illustrate the desired concepts.

Analysis of Interviews

After all the animations had been finished, I conducted a number of informal interviews with subjects who viewed each of the animations to get a more objective view of their quality and effectiveness. I interviewed nine people: three fellow cartographers, three climatologists, and three geography students who had not done extensive work in either cartography or climatology. Each of the three groups of three contained at least one male and female; there were a total of five males and four females.

Each subject was told that they would be viewing three sets of animated maps, the subject of which was tropical cyclones in the North Atlantic Basin; and that after viewing each set, they would be asked a series of questions. The animations were shown in a different order to each of the subjects within each group. Care was taken to make sure that the order of the animations was not repeated within an individual group.

Before each animation was shown, the subjects were read a short description of that animation. They were then allowed to view the animation and ask questions if they wished. After that, the following series of questions were asked:

- Do you think this animation would be useful in teaching? scientific visualization?
- If the animation were to be used in teaching, what age group do you think it should be used with?
- What aspects of this animation did you like the best?
- What aspects do you think could be improved?

After all the animations were viewed, the subjects were asked to comment on which of the animations they preferred and why.

Responses between the groups of climatologists, cartographers, and students differed somewhat and these variations are noted in the following discussion.

HyperCard Evaluation

HyperCard seemed to be the least-liked of the three sets of animations. Both the students and the cartographers thought that these animations would be useful in teaching. The climatologists were more hesitant about this point. They thought that the animation of the 1992 storm season possibly could be used for educational purposes, but were unsure about the others. Most of the subjects seem to like the 1992 animation best, of the three HyperCard animations.

When asked whether the animations would be useful for scientific visualization, both the students and the cartographers seemed uncertain how to respond, however the climatologists agreed on "no." It is likely that this was a difficult question for the subjects to answer, because the term itself was not well understood.

When considering what age group the HyperCard animations might be most appropriate for, the responses were divided. Several thought they would be good for younger children because of the simplicity of the animations. Others thought that they would not be good for younger children because they did not have color, and children would lose interest. All of the subjects agreed that they could be used for students from junior high school through introductory college.

When asked what they liked best about this set of animations the majority of the subjects said they like the storm season animation because of the way it showed the storms in real time. Several subjects said they liked the Anna animation. Most liked it because it showed the wind speed, while one preferred it because of the hurricane symbol.

A unanimous conclusion was that HyperCard would benefit from the use of color. Other suggestions included using different wind speed designations, a clearer legend, and making the symbols in Anna better. Additional suggestions involved adding wind speed to the storm season animation, adding some kind of symbol that would designate one day increments to all three animations, and leaving faint one color trails behind the symbols in both the Anna animation and the storm season animation. It was noted that in several of the cases, the trails in the storm season animation were confused with wind speed; however this was not the case for all the subjects. A few thought that the fading trails was a "nice" effect.

Transform Evaluation

When asked if the Transform animation would make a good tool for either teaching or scientific visualization, the answer was a resounding "yes." All subjects thought it would be best used in junior high or high school at the earliest because of the complexity of the subject and its symbolization. They also thought that it would need a great deal of explanation.

When asked what they liked best about this animation, the color scheme was mentioned most often. Although one person thought that the colors seemed dim, most seemed to think that the blue-purple-red-yellow color scheme was quite effective. Other praise included pattern recognition and detail, and animation smoothness as a result of the moving average approach.

Several of the subjects did have some suggestions for improvements. One subject thought that the animation should be done in a year by year fashion instead of aggregating all fifty years. Others thought that making it larger and adding country boundaries, to help designate land from water would help. And one subject was concerned about having the frequency and wind speed combined onto one map. It was felt that it would be better to have two separate animations, one that showed frequency and one that showed intensity.

Director Evaluation

The subjects seemed to have more opinions about the Director animation than either of the other two sets of animations. Everyone thought that this animation could definitely be used in teaching and visualization tasks. Most of the subjects seemed absorbed in watching it, some playing the storm animation over and over. Most thought it would be good for scientific illustration but probably not for research because the storm patterns shown were "expected;" that is, little new information about hurricanes was added by the animations for research purposes. It was noted, by more than one subject, that the animation gave one a feel for where hurricanes originate, when and where they gain their strength, and the effect that landfall has on them.

Again, subjects were mixed on what they thought was a good age group for this animation. Several said any age, others thought perhaps middle school and up. Everyone agreed that they could definitely be used for college age students.

A majority agreed that color, visual impact, and overall design were some of the best aspects of this animation. Other positive comments included: the use of color to designate hurricane strength, the trails feature, the size of the animation, the amount of data presented, and the use of circle size to represent wind speeds. Not all subjects agreed on the graduated circle issue. Some thought that the circle size was misleading, that it gave one the impression that the storm itself was changing size.

Other improvement issues that were mentioned included: adding more storms, a smoother progression of symbol size, smaller symbols, adding names to the storm trails, and changing the colors in the graduated circle legend to match the colors in the strength legend. Other suggestions included overlaying satellite imagery, changing the symbols to match the storm's actual size, adding landmarks such as cities, and having the trails become transparent or turn gray so that it is easier to see the current storm.

Overall

Table 3 shows a summary of the evaluations of the subjects that were interviewed.

Table 3 Summary of subject evaluations

	HyperCard	Transform	Director
Visual Appeal	poor	excellent	excellent
Usefulness in Teaching	good	good	excellent
Age Group	divided	High school+	Middle school+
Usefulness in Scientific Visualization	poor	excellent	good
Usefulness in Scientific Illustration	fair	excellent	excellent
Overall Preference	not as well liked	well liked	well liked

Overall, the subjects preferred either the Director or the Transform animation over the HyperCard set of animations. One exception was one of the climatology subjects, who preferred the HyperCard animation that showed the entire 1992 storm season. Director was chosen mainly for its colors, its symbology, and its overall design. Transform was preferred for its color scheme and its ability to show when and where tropical storms occur.

Technical and Design Considerations

There are a variety of things that one must consider when making animated maps as opposed to printed static maps. These considerations range from technical decisions concerning software and hardware to design decisions which affect the "look" of the animations.

One of the first things to be considered is what computer platform to use. This choice should be made based on what is available, and the audience that will use the animations. If a Macintosh computer is chosen then screen size is an important choice. Most often a

13 inch screen size with a pixel resolution of 640 by 480 is chosen. This is a fairly standard screen size but it does exclude people with smaller monitors.

Because the screen resolution on most Macintosh monitors is 72 dpi, information that can be shown on screen is much less than can be shown in a printed map that has a resolution of 600 dpi (common laser printer output). It is best to keep detail to a minimum; if a symbol is not necessary, then remove it. This is also important since the viewer should concentrate on what is happening in the animation. If there is extra detail on the map, this becomes confusing and the viewer may be distracted from the primary message.

Color is also an important consideration. It allows more variety and is more interesting for the viewer than monochrome displays. Pale pastel colors work better for background, while bright bold colors work better for symbols. This scheme makes the symbols stand out and not "disappear" into the background. If there are too many colors (or too many bright colors) or if it is not clear what is symbol and what is background, then the viewer tends to be confused.

Symbols that move across the screen may be situated on different background colors; symbol colors should be chosen so that they will be readily visible on any background.

Another factor is the speed of the animation. Selecting an appropriate speed can be a problem because different viewers sometimes prefer different speeds. Occasionally a variety of effects can be seen by speeding up or slowing down the animation. My experience indicates that it is best if some changeability or user interactivity can be built into the animation, so that the user can adjust the speed for their comfort or to see different patterns.

I also found that many of the users became more interested in the animation if they could interact with it. For example, being able to change things such as the speed, the objects displayed, the color scheme, trails behind moving symbols, stopping, starting, forward or backward play, all can increase user interest and learning.

Legends are also important. Just like static maps, animated maps need legends explaining symbols; however, unlike static maps, legends showing the passage of time are usually a crucial but problematic part of the animation. There have been many versions of a time "clock" used in different animations. These include the timeline, the clock, the calendar, and the counter. There is little research on the effectiveness of these different time-legend devices and care should be taken that they are informative but not distracting to the users.

The same principle applies to other parts of the legend. The information must be easily understandable yet not distract from the rest of the animation. In the different animations that I made, I tried having the legend information in different places. I found that having the information all together on the lower part of the screen worked out the best. I also found that information on the bottom right or the top left side of the screen was more likely to be seen then information in the opposite corners.

Another aspect that must be thought about is the use of labels. Since the objects on the screen are often moving around, it is difficult to give them labels. I found the use of labels to be distracting in most cases. If labels are needed, an option is to give the user the choice of turning them "on" or "off." Otherwise, it is probably best to make them as simple and as unobtrusive as possible.

Finally, I would emphasize that simplicity in animations is a virtue; complexity is distracting.

Conclusions

In this thesis I have examined the advantages and disadvantages of using three different software packages in illustrating, through animation, a geographical phenomenon that moves through space and time. I have given a subjective evaluation of the packages based on my experiences and I have summarized comments given by independent observers. Based on the above, it is my opinion that one should not pursue the use of HyperCard as a cartographic animation tool. Because of its crude construction technique, creating animations in HyperCard is so time-consuming that the products are not worthwhile. Without color support, there is very little visual appeal in the animations. However, both Director and Transform should be used as tools for creating cartographic animations. Both of these packages created cartographic animations that were intriguing, visually stimulating, and useful in both scientific visualization and illustration for teaching or for research. It would also be useful to explore the use of Director and Transform to animate other movement phenomena, such as migration and trade, or a phenomenon like rainfall which does not move through space but does change over time.

In general, current desktop animation techniques are primitive, time-consuming, and somewhat crude, however they should not be discarded as a method of producing cartographic animations. Since the use of desktop computers to create cartographic animations is still a relatively new technique, there are still many questions both about how the animations should be created and also about what the animations should include. As the technique evolves, and as the software evolves, using desktop animation techniques to create cartographic animations will only become easier.

APPENDICES

APPENDIX A

DATA DOCUMENTATION

ATLANTIC BASIN BEST TRACK DOCUMENTATION.....BY CHRIS LANDSEA (2/16/95)

This documentation is based upon "A tropical cyclone data tape for the North Atlantic basin, 1886-1983: Contents, limitations, and uses", _NOAA Technical Memorandum NWS NHC 22_, 1984 written by B.R. Jarvinen, C.J. Neumann, and M.A.S. Davis. The North Atlantic 'best track' (so named as it is the 'best' track and intensity estimates of tropical cyclones as determined in a post-analysis of all available data) is maintained by the forecasters and researchers at the National Hurricane Center in Miami, Florida. Permission to make free access of this data and documentation were provided by Dr. Robert Sheets - director of NHC and by Mr. Neal Lott of the National Climatic Data Center in Asheville, NC. Questions regarding the format and/or errors in the documentation/data should be directed to Chris Landsea (landsea@downdry.atmos.colostate.edu).

Currently, the database extends from 1886 to 1993. The database filename is 'tra86to93.atl. Updates for the coming year will be provided as soon as the analysis is final at NHC. So, I hope this data provides some insight into the workings of the Atlantic hurricane for you as it, to some degree, has for me........CWL

Note that the 'tra86to93.atl' file is UNIX compressed to save space on our computer so that the filename is 'tra86to93.atl.Z'. To read the file after you've ftp'ed it, you need to UNCOMPRESS the file. Otherwise, you can't access the data.

$$

P.S. Though the data extends back to 1886, one is cautioned in deriving seasonal statistics back that many years. The advent of aircraft reconnaissance in 1944 is suggested (both by myself and C.J. Neumann) to be the start of reliable seasonal statistics on the frequency and duration of storms. However, as reported in Landsea (1993) ["A climatology of intense (or major) Atlantic hurricanes", _Mon. Wea. Rev._, 121, 1703-1713], there is a bias in the best track data in that strong hurricanes were over-reported in windstrength for the years 1944 to 1969 (and possibly before 1944 as well). This bias amounted to a five knot overestimation at the 100kt threshold for major hurricane status. The amount of overestimation is even worse for yet stronger storms.

$$

There are three basic types of datalines in the Best Track.

```
TYPE A:
92620 08/16/1992  M=13  2 SNBR= 899 ANDREW      XING=1 SSS=4
Card# MM/DD/Year  Days S# Total#... Name........US Hit.Hi US category

TYPE B:
92580 04/22S2450610  30 1003S2490615  45 1002S2520620  45 1002S2550624  45 1003*
Card# MM/DD&LatLongWindPress&LatLongWindPress&LatLongWindPress&LatLongWindPress

TYPE C:
92760 HRCFL4BFL3 LA3
Card# TpHit.Hit.Hit.
```

....

TYPE A:

Card# = Sequential card number starting at 00010 in 1886

MM/DD/Year = Month, Day, and Year of storm

Days = Number of days in which positions are available (note that this also means number of lines to follow of type B and then one line of type C)

S# = Storm number for that particular year (including subtropical storms)

Total# = Storm number since the beginning of the record (since 1886)

Name = Storms only given official names since 1950

US Hit ='1' = Made landfall over the United States as tropical storm or hurricane,   '0' = did not make U.S. landfall

Hi US category = '9' = Used before 1899 to indicate U.S. landfall as a hurricane of unspecified Saffir-Simpson category

'0' = Used to indicate U.S. landfall as tropical storm, but this has not been utilized in recent years

'1' to '5' = Highest category on the Saffir-Simpson scale that the storm made landfall along the U.S. '1' is a minimal hurricane, '5' is a catastrophic hurricane

....

TYPE B:

Card# = As above.

MM/DD = Month and Day of Storm

& = 'S' (Subtropical stage), '*' (tropical cyclone stage), 'E' (extratropical stage), 'W' (wave stage - rarely used)

LatLong = Position of storm: 24.5N, 61.0W

Wind = Maximum sustained (1 minute) surface (10m) windspeed in knots (in general, these are to the nearest 5 knots).

Press = Central surface pressure of storm in mb (if available). Since 1979, central pressures are given everytime even if a satellite estimation is needed.

Positions and intensities are at 00Z, 06Z, 12Z, 18Z

....

TYPE C:

Card# = As above.

Tp = Maximum intensity of storm ('HR' = hurricane, 'TS' = tropical storm, 'SS' = subtropical storm)

Hit = U.S. landfallings as hurricane ('LA' = Louisiana, etc.) and Saffir-Simpson category at landfall ('1' = minimal hurricane...'5' = super hurricane). (Note that Florida and Texas are split into smaller regions: 'AFL' = Northwest Florida, 'BFL' = Southwest Florida, 'CFL' = Southeast Florida, 'DFL' = Northeast Florida, 'ATX' = South Texas, 'BTX' = Central Texas, 'CTX' = North Texas.)

Here are two sample storms from the original data:

```
80310 08/25/1979 M=15  4 SNBR= 777 DAVID        XING=1 SSS=2
80320 08/25*  0    0    0    0*  0    0    0    0*117 361   25 1008*117 382   25 1007*
80330 08/26*117 403   30 1006*116 422   35 1005*116 440   40 1003*116 455   45  998*
80340 08/27*117 470   55  990*118 485   65  980*118 500   80  966*119 515   95  954*
80350 08/28*122 529  115  947*125 544  125  941*128 557  130  938*132 569  125  941*
80360 08/29*137 580  120  944*142 592  120  942*148 603  125  938*153 616  125  933*
80370 08/30*156 628  130  929*160 642  140  925*163 652  145  924*166 662  150  924*
80380 08/31*168 673  145  927*170 683  145  928*172 691  145  927*179 697  150  926*
80390 09/01*188 704  130  953*193 720  100  978*197 737   65 1002*206 746   60 1002*
80400 09/02*213 752   65  997*219 755   70  990*230 763   70  984*239 774   75  979*
80410 09/03*246 782   80  976*253 791   80  974*263 796   85  973*272 802   85  972*
80420 09/04*280 805   85  971*291 808   85  970*302 809   85  970*315 812   80  970*
80430 09/05*325 811   65  972*335 809   55  976*349 806   45  980*362 801   40  984*
80440 09/06*376 795   40  987*392 785   40  989*415 763   40  991E433 737   40  992*
80450 09/07E450 700   45  991E465 660   50  988E475 615   50  987E500 570   55  986*
80460 09/08E525 525   60  985*  0    0    0    0*  0    0    0    0*  0    0    0    0*
80461 HRCFL2DFL2 GA2 SC2

83220 11/03/1981 M= 5 11 SNBR= 804 KATRINA      XING=0
83230 11/03*169 812   25 1005*172 813   25 1005*175 814   25 1004*178 814   30 1002*
83240 11/04*181 814   30 1001*183 814   35 1000*186 813   40  998*189 812   50  996*
83250 11/05*192 811   60  993*196 808   65  988*200 805   75  980*204 801   70  988*
83260 11/06*209 795   65  996*216 783   55  999*224 770   50 1001*232 755   45 1001*
83270 11/07*240 733   40 1001*250 706   40 1002*259 675   40 1002*268 645   40 1002*
83280 HR
```

APPENDIX B

HYPERCARD

Instructions for Creating HyperCard Animations

The HyperCard animations were created by placing a series of images on cards within each stack. Once the images had been placed, HyperText scripts were written to cycle the images in an animated fashion, and to run the "clock." The following are the scripts used in each of the HyperCard animations.

HyperText Scripts

Hurricane Debbie

• Script of play button:

```
on mouseUp
  put 13 into theDay
  go to the next card
  show bg field month
  show bg field date
  set hilite of bg button play to true
  repeat 11 times
    add 1 to theDay
    put theDay into bg field date
    wait 1 seconds
    go to next card
  end repeat
  hide bg button play
end mouseUp
```

• Script of Start Over button:

```
on mouseUp
  hide bg field month
  hide bg field date
  set hilite of bg button play to false
  show bg button play
  go to card 1
end mouseUp
```

Tropical Storm Anna

• Script of Play button:

```
on mouseUp
  put 24 into theDay
  put "July" into theMonth
  put 0 into theHour
  put theDay into bg field date
  put theMonth into bg field month
  put theHour into bg field hour
  go to the next card
  show bg field month
  show bg field date
  show bg field hour2
  show bg field hour
  set hilite of bg button play to true
  repeat 12 times
    put 0 into theHour
    put theHour into bg field hour
    show bg field hour
    if theDay > 30 then
      put 1 into theDay
     put "August" into theMonth
      put theMonth into bg field month
      put theDay into bg field date
      wait 20 ticks
      go to next card
    else
      add 1 to theDay
      put theDay into bg field date
      show bg field date
      wait 20 ticks
      go to next card
    end if
    repeat 3 times
      add 6 to theHour
      put theHour into bg field hour
      put theDay into bg field date
      show bg field month
      show bg field date
      show bg field hour
      wait 20 ticks
      go to the next card
    end repeat
  end repeat
  hide bg field month
  hide bg field date
  hide bg field hour
  hide bg field hour2
  hide bg button play
end mouseUp
```

• Script of Start Over button:

```
on mouseUp
  hide bg field month
  hide bg field date
  set hilite of bg button play to false
  show bg button play
  go to card 1
end mouseUp
```

1992 Storm Season

• Script of Play button:

```
on mouseUp
  put 15 into theDay
  put "August" into theMonth
  go to the next card
  show bg field month
  show bg field date
  set hilite of bg button play to true
  repeat 19 times
    if theDay > 30 then
      put 1 into theDay
      put "September" into theMonth
      put theMonth into bg field month
      put theDay into bg field date
      wait 25 ticks
      go to next card
     else
      add 1 to theDay
      put theDay into bg field date
      wait 25 ticks
      go to next card
    end if
  end repeat
  repeat 13 times
    put theMonth into bg field month
    add 1 to theDay
    put theDay into bg field date
    show bg field month
    show bg field date
    wait 30 ticks
  end repeat
  go to the next card
  put theMonth into bg field month
  show bg field month
  show bg field date
  repeat 23 times
    if theDay > 29 then
      put 1 into theDay
      put "October" into theMonth
      put theMonth into bg field month
```

```
      put theDay into bg field date
      wait 25 ticks
      go to next card
    else
      put theMonth into bg field month
      add 1 to theDay
      put theDay into bg field date
      wait 25 ticks
      go to next card
    end if
  end repeat

  repeat 12 times
    put theMonth into bg field month
    add 1 to theDay
    put theDay into bg field date
    show bg field month
    show bg field date
    wait 30 ticks
  end repeat
  go to the next card
  put theMonth into bg field month
  show bg field month
  show bg field date
  repeat 15 times
    if theDay > 30 then
      put 1 into theDay
      put "November" into theMonth
      put theMonth into bg field month
      put theDay into bg field date
      wait 25 ticks
      go to next card
    else
      put theMonth into bg field month
      add 1 to theDay
      put theDay into bg field date
      wait 25 ticks
      go to next card
    end if
  end repeat
  hide bg button play
end mouseUp
```

• Script of Start Over button:

```
on mouseUp
  hide bg field month
  hide bg field date
  set hilite of bg button play to false
  show bg button play
  go to card 1
end mouseUp
```

For all three animations

- Script of Quit button:

```
on mouseUp
  answer "Quit HyperCard?" with "OK" or "Cancel"
  if it is "OK" then
    doMenu "Quit HyperCard"
  else
    answer "Glad you reconsidered" with "No problem"
  end if
end mouseUp
```

- Stack Script:

```
on open
  go to card 1
end open
```

APPENDIX C

TRANSFORM

To import the data into Transform I went through the following steps:

- Open the text (.txt) file
- Select "text columns" from the list data types that can be imported [<OK>]
- For the delimiters select "commas only" [<OK>]
- Configure using the information below:

Longitude	-110	10	0.5
Latitude	5	65	0.5
Wind speed	10	165	

- Specify
  Data Placement: sum values
  Background Value: -1
- Fill Method: No fill
  click <OK> and the data matrix appears
- select <numbers – smooth data – 5 – OK>
- a new matrix appears
- select <image – interpolated image>
- an image appears
- set the min and max for best use of color and replot
- adjust the position of the image to 0,0
- adjust the <rectangle size>, zoom=2
- overlay outline map image from scrapbook
- deselect <show axis>
- from the tables menu select a color table ("Space")
- Now save the image as a transform file and then under a different name as a pict file

I used the Open command to open the text (.txt) file. Then I selected "text columns" from the list data types that can be imported. For the delimiters I selected "commas only." To configure the file so that each image would be the same I used the information listed above. I then specified [Data Placement = sum values] so that Z values that fell on top of one another would be added together and [Background Value = -1] so that the background value would be different from all the data. By specifying [Fill Method = No fill] my data was placed in the matrix, and cells without data were not filled in. By clicking <OK> and the data matrix appears. Once the data matrix appeared, I created a new matrix of smoothed values by selecting <numbers – smooth data – 5 – OK>. This smoothed my data values with five iterations. When the new data matrix appeared, I selected <image – interpolated image>. This created an interpolated image of my data. I then went through a series of adjustments to enhance the look of the image and to make sure that each image had the same parameters as the others. I set the minimum and maximum values for the color range, adjusted the position of the image to (0,0), adjusted the rectangle size to zoom=2, overlaid an outline map from the "scrapbook" onto the image, and deselected <show axis> so that the numbers along the x and y axis disappeared. From the tables menu, I selected the color table "Space." I then saved the image as a transform file and then under a different name as a pict file.

I followed the above sequence for each image to be used in the final animation. I then re-opened each pict file and placed the timeline, created in Freehand, into the overlay. This allowed the map user to see what time of year different patterns appeared or disappeared. Once all the fames had been created, the animation was viewed in a companion program called "View." This program allows the map user to control the speed of the animation, to start or stop the animation on any given frame, and to change the color table used.

APPENDIX D

DIRECTOR

Instructions for Creating the Director Animation

After the castmembers had been imported or created in Director, and after they had been place in appropriate positions on the stage, the following Lingo Scripts were used to create the animation.

Lingo Scripts

• First Frame (Score)

```
on enterFrame
  puppetsprite 4, TRUE
end

on exitFrame
  installMenu 40
  global t
set t = 20
  set the checkMark of menuItem 3 of menu "speed" to true
  set the text of Cast 29 = "   "
  set the enabled of menuItem 1 of menu "Trail" to TRUE
  set the enabled of menuItem 2 of menu "Trail" to FALSE
  set the textSize of field 29 = 18
  set the textFont of Field 29 = "Gill Black SSI"
end exitFrame
```

• Second & Fourth Frame (Score)

```
on exitFrame
  go to the frame
end

on enterFrame
  set the text of cast 10 = EMPTY
  set the text of cast 11 = EMPTY
  set the text of cast 12 = EMPTY
  set the text of cast 13 = EMPTY
  set the text of cast 30 = EMPTY
  set the text of cast 31 = EMPTY
  set the text of cast 32 = EMPTY
end
```

• Menu (Cast Member)

```
menu: @
About... ≈ about
menu: File
Quit/Q ≈ quit
menu: Storm
1992, Andrew ≈ set the text of cast 29 = "ANDREW"
1969, Camille ≈ set the text of cast 29 = "CAMILLE"
1988, Gilbert ≈ set the text of cast 29 = "GILBERT"
1985, Gloria ≈ set the text of cast 29 = "GLORIA"
1989, Hugo ≈ set the text of cast 29 = "HUGO"
menu: Speed
Very Fast≈ put vfast() into t
Fast ≈ put fast() into t
Medium ≈ put med() into t
Slow ≈ put slow() into t
Very Slow ≈ put vslow() into t
menu: Trail
Trail On ≈ trailOn
Trail Off ≈ trailOff
Clear Trails/C ≈ clear
```

• Apple menu scripts

```
on about
  set the fileName of window "aboutme" to "aboutme"
  set the rect of window "aboutme" =rect(75, 50, 275, 150)
  set the windowType of window "aboutme" to 3
  open window "aboutme"
end about
```

• Speed Menu Scripts

```
on vFast
  set t=1
  repeat with i=1 to 4
    set the checkMark of menuItem i of menu "speed" to false
  end repeat
  set the checkMark of menuItem 1 of menu "speed" to true
  return t
end vfast

on Fast
  set t=10
  repeat with i=1 to 4
    set the checkMark of menuItem i of menu "speed" to false
  end repeat
  set the checkMark of menuItem 2 of menu "speed" to true
  return t
end fast
```

```
on Med
  set t=20
  repeat with i=1 to 4
    set the checkMark of menuItem i of menu "speed" to false
  end repeat
  set the checkMark of menuItem 3 of menu "speed" to true
  return t
end Med

 on Slow
  set t=40
  repeat with i=1 to 4
    set the checkMark of menuItem i of menu "speed" to false
  end repeat
  set the checkMark of menuItem 4 of menu "speed" to true
  return t
end Slow

on VSlow
  set t=60
  repeat with i=1 to 4
    set the checkMark of menuItem i of menu "speed" to false
  end repeat
  set the checkMark of menuItem 5 of menu "speed" to true
  return t
end VSlow
```

• Trail Menu Scripts

```
On trailOn
  go to frame 5
  set the enabled of menuItem 2 of menu "Trail" to TRUE
  set the enabled of menuItem 1 of menu "Trail" to FALSE
end trailOn

On trailOff
  puppetTransition 49, 0, 2, FALSE
  go to frame 2
  set the enabled of menuItem 1 of menu "Trail" to TRUE
  set the enabled of menuItem 2 of menu "Trail" to FALSE
end trailOff

on clear
  puppetTransition 49, 0, 2, FALSE
end clear
```

• Reading Files

```
on readFile fname
  put FileIO(mNew, "read", fname) into gVarObject
  set theVText = EMPTY
  put gVarObject(mreadline) into theline
  repeat while (theline <>EMPTY)
    if char length(theline) of theline=RETURN then
      put "" into char length(theline) of theline
    end if
    set theVText=theVText & theline
    put gVarObject(mReadLine)into theline
  end repeat
  gVarObject(mdispose)
  return theVText
end
```

• "Click Me" – Running the animation

```
on mouseUp

  --  sets up global variables

  global gVarObject
  global dataList
  global n

  --  calls subroutines from movie scripts

  put the text of cast 29 into n
  if n="   " then
    alert "Before playing this animation you must first select
 the storm you wish to view from the STORM menu."
  else

    readFile (n & "x.txt")
    set dataXList=the result

    readFile (n & "y.txt")
    set dataYList=the result

    readFile (n & "z.txt")
    set dataWList=the result

    readFile (n & "d.txt")
    set dataDList=the result

    readFile (n & "h.txt")
    set dataHList=the result
```

```
     --  calculates the length of the file
and sets a value for the variable r

     put length(dataXList) into noChars
     set r=1
     set q=1
     set p=1

     --  sets up a repeat structure that repeats
from 1 to the total number of Longitudes in the
file reading a new set of numbers each time
     --  it sets size, color and position of the
hurricane symbol
     --  it shows on the screen the windspeed (stage,
Latitude and Longitude)

     Repeat with counter = 1 to (noChars/3)

       set c=EMPTY

       put chars(dataXList, r, r+2) into X
       put chars(dataYList, r, r+2) into Y
       put chars(dataWList, r, r+2) into Z
       put chars(dataDList, q, q+1) into M
       put chars(dataDList, q+2, q+3) into D
       put chars(dataDList, q+4, q+5) into E
       put chars(dataHList, p, p+1) into H

       Set Z= Z * 1.15

       set the text of cast 12 = integer(Z) && "MPH"
       set the text of cast 10 =
         string(integer((value(X)/5.3)-110)) && "Degrees"
       set the text of cast 11 =
         string(integer((((value(Y)-30)/5.3)-65)*(-1))) && "Degrees"

if value(M) = 01 then
         set the text of cast 30 = "January"
       else if value(M) = 02 then
         set the text of cast 30 = "February"
       else if value(M) = 03 then
         set the text of cast 30 = "March"
       else if value(M) = 04 then
         set the text of cast 30 = "April"
       else if value(M) = 05 then
         set the text of cast 30 = "May"
       else if value(M) = 06 then
         set the text of cast 30 = "June"
       else if value(M) = 07 then
         set the text of cast 30 = "July"
       else if value(M) = 08 then
         set the text of cast 30 = "August"
       else if value(M) = 09 then
         set the text of cast 30 = "September"
```

```
        else if value(M) = 10 then
          set the text of cast 30 = "October"
        else if value(M) = 11 then
          set the text of cast 30 = "November"
        else if value(M) = 12 then
          set the text of cast 30 = "December"
        end if

set the text of cast 31 =string(integer(D)&","&&"19"&E)
        set the text of cast 32 =string("HR:"&&H)

if value(Z) < 74 then
          set c= 5
          set the text of cast 13 = "Tropical Storm"
        else if value(Z) >= 74 and value(Z) < 96 then
          set c= 11
          set the text of cast 13 = "Class 1 Hurricane"
        else if value(Z) >= 96 and value(Z) < 111 then
          set c= 17
          set the text of cast 13 = "Class 2 Hurricane"
        else if value(Z) >= 111 and value(Z) < 131 then
          set c= 23
          set the text of cast 13 = "Class 3 Hurricane"
        else if value(Z) >= 131 and value(Z) < 155 then
          set c= 29
          set the text of cast 13 = "Class 4 Hurricane"
        else if value(Z) >= 155 then
          set c= 35
          set the text of cast 13 = "Class 5 Hurricane"
        end if

        set the locH of sprite 5 to Value(X)
        set the locV of sprite 5 to Value(Y)

        set the forecolor of sprite 5 to c
        set the height of sprite 5 to value(((Z-10)/5)+10)
        set the width of sprite 5 to value(((Z-10)/5)+10)
        updateStage

startTimer
        repeat while the timer < Value(t)
          nothing
        end repeat

        set r=r+3
        set q=q+6
        set p=p+2

      end repeat
    end if
end
```

APPENDIX E

INTERVIEW MATERIALS

Copy of the Consent Form

Consent Form

1. I have freely consented to take part in a study being conducted by Catherine Van Vliet Mey. I will be participating in a study on animated map design.

2. The study has been explained to me, and I understand the explanation that has been given and what my participation will involve.

3. I understand that I am free to discontinue my participation at anytime without penalty. I understand that the expected length of my participation is approximately 10 minutes.

4. I understand that the results of my participation in the study will be kept in strict confidence, as will those of all other individuals participating. In other words, all participants will remain anonymous in the reporting of the results.

5. I understand that, at my request, I can receive additional explanation of the study after my participation is completed.

Signed:

Date:

Copy of the Interview Information & Questions

Subject Name: Date:
Climatologist–Cartographer–Student

Animation:
1) Do you think this animation would be useful in:
Teaching?
Scientific Visualization?

What age group would you use it with?

2) What do you think this animation is trying to show?

3) What did you like best about this animation? Why?

4) What do you think could be improved? Why?

The same questions were asked for each set of animations and then the following questions was asked:

Which of the three sets of animations do you prefer? Why?

The following information was given to the subjects:

I will ask you a series of questions as you view three different sets of animated maps. The subject of each of these animations will be tropical cyclones in the North Atlantic Basin.

Read to them the consent form.

Transform:

This animation shows 50 years worth of hurricane information aggregated into a one year time span. Please note the timeline along the bottom the animation. Each frame of the animation shows a four week block of time (ie it shows all the storms that occurred in that four week block from the year 1944 to 1993). For each frame that one year block moves forward one week. (so if this frame was showing week 1, 2, 3, & 4; the next frame would show week 2, 3, 4, & 5)

The colors are an index of windspeed and frequency– the blues represent low windspeed and low frequency, the yellows indicate high windspeed and high frequency.

You can change the speed of the animation by changing the number at the bottom.

HyperCard:

This set of animations contains three different animations. One shows hurricane Anna, one shows hurricane Debbie, and one shows all the storms in the 1992 hurricane season.

Hurricane Anna: This animation shows hurricane anna, note the colors indicate wind-speed in knots, and there is a clock in the upper right hand corner (a knot = one nautical mile per hour or about 1.15 mph)

Hurricane Debbie: This animation shows hurricane debbie, this animation shows the track of the storm as it move across the atlantic. Clock in upper right hand corner.

1992 Hurricane Season: This animation shows all the storms that occurred during the 1992 storm season. Note that there are two time periods when there are no storms occurring however the clock (in the upper right hand corner) continue to count off the days.

Director:

In this animation you view one storm at a time however you can choose which storm to view (from a group of five famous storms) by picking a storm from the storm menu. You can also change the speed of the animation and whether or not you want it to leave a trail of the storm. Note you can see statistics about the storm on the bottom of the screen. Click the button that says click me to start the animation.

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