Review: Evaluation of Static and Animated Visualization in Meteorology

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Abstract- Data from environmental studies are measured, stored and analyzed to find out the impact of climate change. Visualizing an environment data is quite a challenging process. Predicting future variations of specific variables such as wind speed, precipitation and temperature involve complex processes of numerical analysis and interpretations. The goal of this paper is to study both type of visualization - static and animated visualization to discover the application and advancement in meteorology. Focusing on two types of meteorology - temperature and wind speed, few examples are emphasized to show meteorology application in both type. Common type of heatmap and graph are used in static visualization. In order to combine multidimensional from static visual together and simplify it into one visual, animated visualization able to play the role. Furthermore, this paper also reports on the element used in the visualization and how it enhances the image in order to deliver information to the readers.
Keywords: Static visualiztion; animated visualization; Meteorology.

I. INTRODUCTION

Meteorology is a branch of scientific study for environmental or atmosphere chemistry and physics with a major focus on weather forecasting which is a most needed areas of science for everyday lives. Analyzing an environmental datasets is a very complex and demanding tasks without the help of the visualization. With the help of the visualization hidden patterns of the raw data can be found more easily. The visualization on meteorology provides researcher, public, stakeholders and policy makers with climate change data, graphical presentation with visualization technique which is very effective for the decision making strategies. The researcher are able to focus more on the problems to achieve their goals. There are a lot of visualization tools available but each tool has its own purpose. The researcher are finding difficult to select the suitable tool for their problems. Researcher need to consider on the features, applicability, strength and limitations of the tool before choosing the right ones for their projects. Another issue that are being faced by the researchers are visualizing the data using the numbers is not easy to picturize certain aspect of the atmosphere. Not all the meteorological factors can be visualized, but it can be visualized the way it effects the surroundings.

There are several aspects that need to be considered when analyzing the meteorological data. We need to identify how they interact and what are the changes or result on the environment. The important elements of the meteorological data are air temperature, humidity, air pressure, wind speed and precipitation (amount of rainfall). These meteorological data need to be divided into categories that can be visualized directly and those that cannot.

1.1 Air Temperature

Air temperature is one of the most fundamental factors on the meteorological data. It measures the amount of the heat energy presents in the air. It's not a visible phenomenon but the effects on the surroundings are noticeable. Drop in temperature can cause wet roads to turn in ice, farmers' crops to be damaged. Extremely high temperatures can dangerous to the health of people, plants and animals such as heat stroke. Temperature can be visualized using graph and heat maps.

The meteorologist used thermometer to measure the temperature. The air temperature can be vary depending on the distance above the ground. The meteorologist measure the temperature around 1.25m to 2m from the ground for the surface temperature. The thermometer are installed in a weather station to protect it from wind, direct sunlight and moisture to get the accurate reading.

1.2 Wind Speed

Another phenomena which is not visible is the wind speed and its direction. Metrologies also observe wind speed to help determine changes in the weather. Strong wind indicates that the weather may be changing. The speed of the wind increases as a thunderstorms approaches. The molecules in the air cannot be seen but their interaction by observing leaves fluttering in the tree, flags flapping, waves on the water getting bigger and windmills can be observed measured and possible to be visualized.

Anemometer is used to measure the strength and the speed of the wind for visualization aspects. There are various type of anemometers and it is very important for us to select the rights ones to model and visualize. Windmill shaped anemometer is the combination of a wind vane and anemometer. It is most suitable anemometer when visualizing wind data because wind direction should also be taken into account. Wind speed will make sure the rotation of the windmill and the direction affects the wind vane. The above mention technique can be manipulated easily for modelling the visualization. Wind maps are one of the great ways to visualize wind patterns across the regions.

II. STATIC AND ANIMATED VISUALIZATION

The visualization concept was introduced to provide better computer graphics tools for visualization of scientific results. The purpose of the visualization is to evaluate the parameters and their interaction to provide better insight into the nature of the data, better understanding of the model behaviour and better support for the analysis of the problems. Visualization can be categorized into two types mainly, such as static and animated.

2.1 Static Visualization

Static visualizations commonly used as image in web or printed form. Readers are not able to go behind the image to explore more information. It is insufficient to make critical evaluation especially in small sample size studies (Weissgerber, 2016).

2.2 Animated Visualization

Interactive or animated visualizations allow to see actions behind the image. High workload and complexity of the image may encourage visualization in animated form (Lowe, 1999). It is simpler to discover the details behind images as the images can unfold the action by itself. Commonly seen on the web or television as commercial, dynamic images is frequently used in few domains such as weather forecasting and computational fluid dynamics. Advances in animation technologies have vastly improved visualization of information involving speed, projection and vector of travel (Rieber et al. 1990; Rieber 1991a; Rieber 1991b; Chan Lin 1998).

III. VISUALIZATION IN METEOROLOGY

The metrological data presentation is a very challenging scientific visualisation application because of the nature of the data itself. Modelling a scene in order to visualize data consist of modelling a scenery after a real world and visual representations of the data. The metrological data's mostly are available in 3 dimensional spaces with many parameters in one time.

More powerful graphics and technique has been introduced and the amount of model data to analyze has increased. These will also increase the complexity in the relationship of the parameters happens.

3.1 Dimensional Weather Data

Better software and hardware has been found to introduce new technique to visualize more information within the given time. One-Dimensional and Two-Dimensional techniques have been replaced by Three-Dimensional and Four-Dimensional technique with the availability of the high quality computer display devices. The complexity of the user interaction is also increasing from time to time. Users are able to roll over the mouse to change the visualization by suing some functions such as zooming, moving the maps to all the direction and etc.

Data values that correspond to one variable are called one-dimensional data set, where only one value per each data. Two-dimensional are categorized as the result of combination of two variables such as temperature and humidity. The combination of three variables is classified as three-dimensional and multi-dimensional is a combination of more than three variables.

Atmospheric pressure and wind velocity are classified as one-dimensional environmental data. Some of the example of data visualization for one-dimensional are histograms and normal distribution.

The common two-dimensional visualization form is scatterplot, line graph, bar chart. Data usually represented by points, line or area in the coordinate systems to show relation. The colours can be used to show the differences of two or more data sets in the same coordinate.

The visualization use of three dimensional techniques provides more information within a reasonable time. More information will be displayed on the same chart to help analysing the problems. The third dimension can be achieved by adding furthers axis and orthogonal in scatterplot and bar chart.

Multi-dimensional or high-dimensional data consist of more than 3 considerable variables. Several techniques are available to understand on the relations between multiple variables but the basic problem address by multidimensional data is the development of technique for high dimensional data. Adding colour in the visualization is one of the techniques used to add dimension. We have to consider a lot of factor when adding

colours to create the dimension. Multidimensional data also can be display using glyphs. It is drawn according to its multidimensional data point and it changes its appearance according to the data presented. The similarity and differences that can be noticed from the features of the glyphs can let us to identify the original data. Star plots and Chernoff faces two type of glyphs. Projection is also another useful technique for displaying multidimensional data. It relatively will enable the data to be projected into a smaller subspace in hope that various multidimensional structures reveal in lower dimensions.

IV. VISUALIZATION IN TEMPERATURE AND WIND SPEED

4.1 (a) Static Visualization: Temperature

Fig. 1. showed temperature, humidity and Pressure visualization in form of graph. The static form graph is line graph. Commonly normal line graph have year as x-axis and value at y-axis. Above is the example of temperature graph by time.

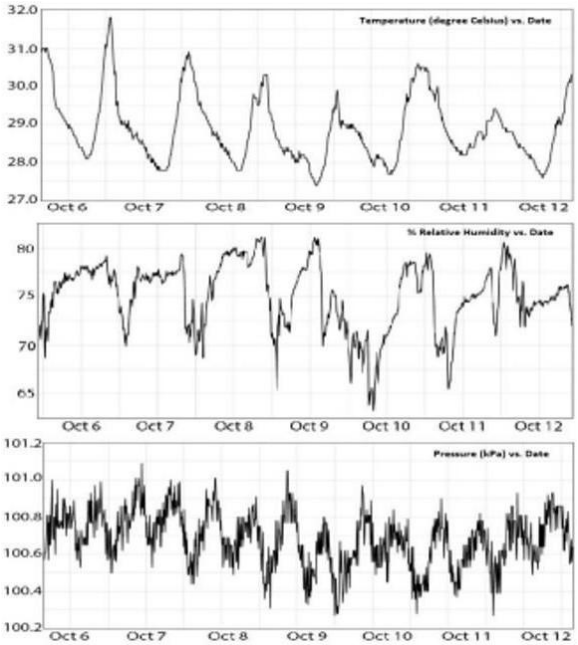


Fig. 1. Temperature, Humidity and Pressure Visualization in form of Graph.

Fig. 2. showed the second example of static visualization of temperature information is in form of heat map. It delivers the temperature changes comparison across multiple cities to see temperature concentration. Moreover, heat map can also be used in animated version when having time or years as manipulated parameter. Heat map uses different colours as the main design element. The colour shows concentration or amount of measurement and represents variety in the data.

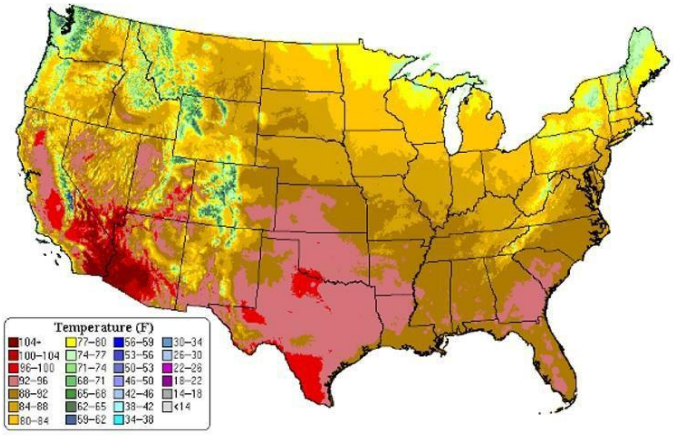


Fig. 2. Typical Maximum Daily Temperature in July.

4.1 (b) Animated Visualization: Temperature

As stated before, heat map can be used in animated version when time parameter included in the visual. It is to show the changes of temperature throughout the time.

According to Clarke (2016), Fig. 3. in animated form is retrieved from climatemaps. It shows the detail of the weather throughout the year covering the whole world. Plus, it is able to reveal the changes or movement of temperature for places. In addition, this type of map has the ability to zoom in detail for particular country, state and even city in order to reach more detailed information regarding a place.

Addition to temperature parameter, choices can be made from the drop-down menu for precipitation and cloud cover animated visualization.

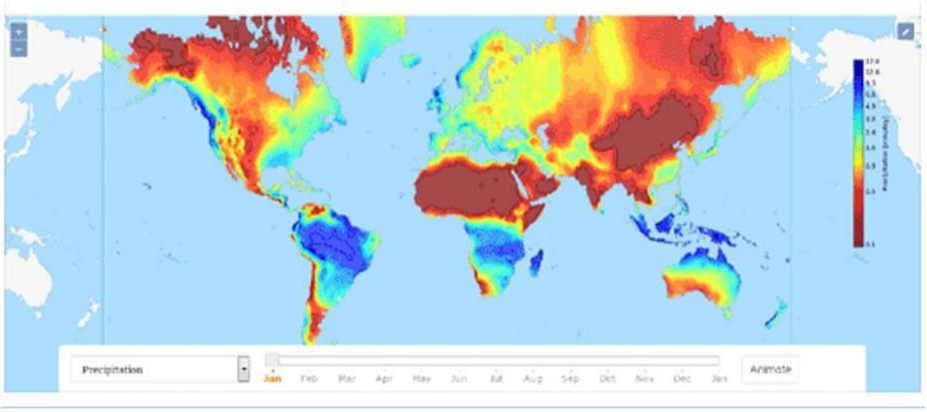
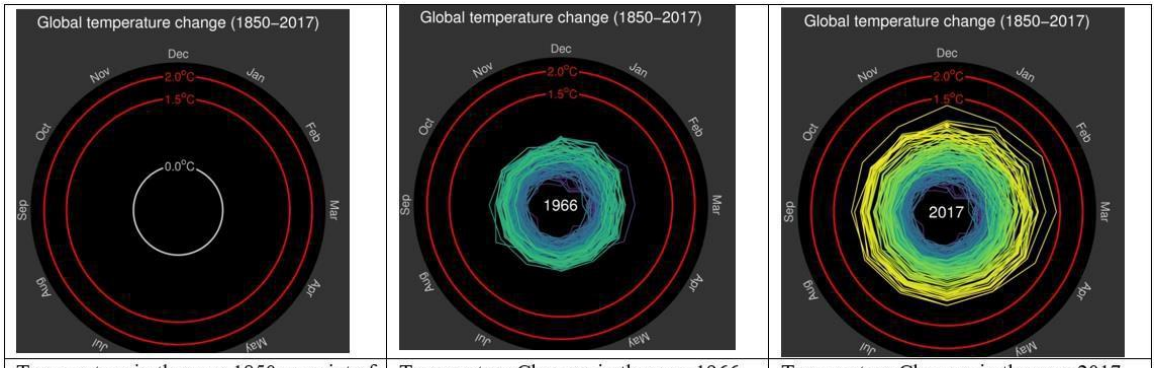


Fig. 3. Animated climatemaps.

Besides that, based on Freedman, a new way of visualizing temperature has been delivered by Ed Hawkins in order to emphasize the progress caused by global warming. Essential element of temperature visualization is the combination of line as the mark of temperature, spiral to mark current temperature and colour to emphasize on the temperature increment. This animated visualization is one of many ways to deliver historically changes to audience. In the opening ceremony of the Rio Olympics, this visualization was used to discuss regarding climate change. The visualization is straight forward method as the changes through the year are obvious. This spiral visualization has been modified to 3D version, tornado version and added few studies include carbon dioxide and carbon.

Fig. 4. (Hawkins, 2016) showed visualization of three different years. During the year 1850 when the first data was collected the temperature was set to be 0 as the reference point. In the year 1966, while in the year 2017 the global temperature change is nearly 1.5 Celsius.



Temperature in the year 1850 as point of reference	Temperature Changes in the year 1966	Temperature Changes in the year 2017

Fig. 4. Visualization of three different years.

4.2 (a) Static Visualization: Wind Speed

Fig. 5. and Fig. 6. emphasize on the wind speed throughout the time and wind direction and at different speed respectively. Colour is used in the Fig. 6 to differentiate between three speeds.

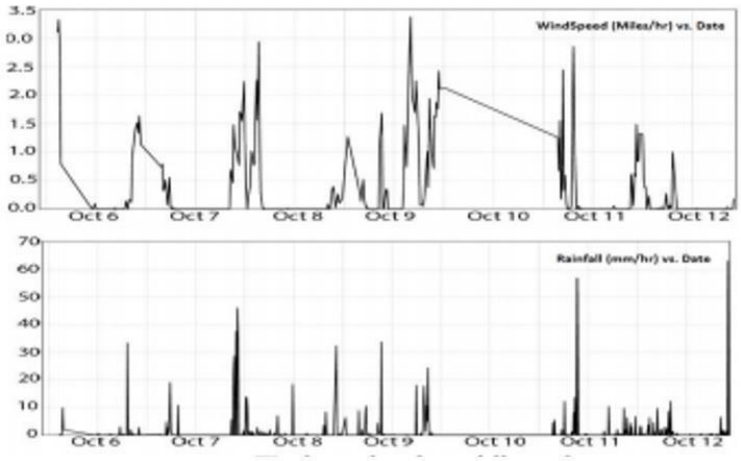


Fig. 5. Static Visualization of Wind Speed and Rainfall.

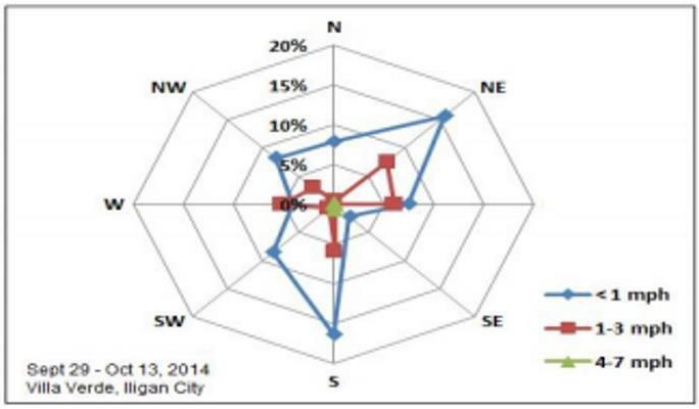


Fig. 6. Static Visualization of Wind Speed and Direction in Rose Graph.

Fig. 7 showed the heatmap where speed is be used as variable. Limitation to above picture is the absence of direction of the wind and time.

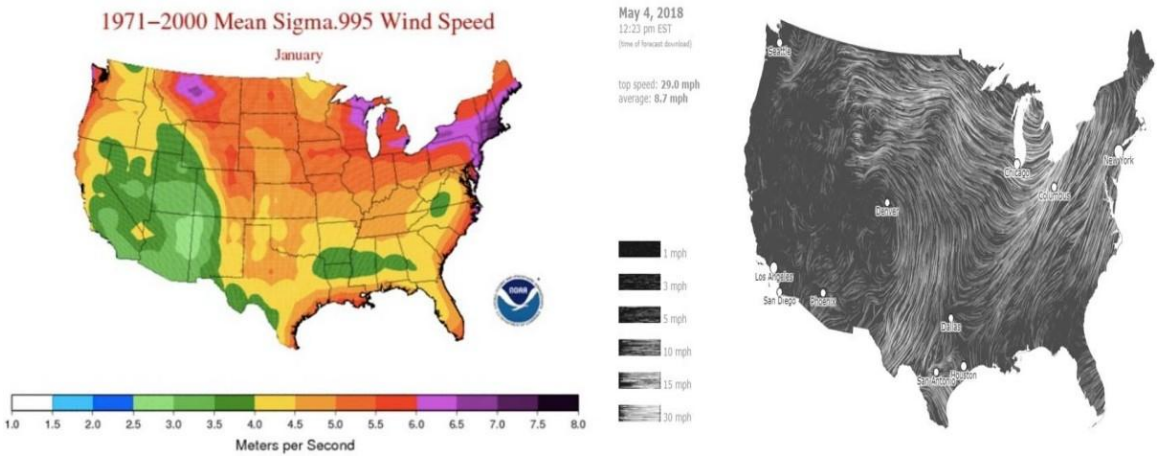


Fig. 7. Heatmap. Fig. 8. Wind map

4.2 (b) Animated Visualization: Wind Speed

The advantages of animated visualization it can combine the wind speed with direction throughout the year. As static visualization gives separate info at two different graphs, animated is seen as an effective way to combine all those parameters into one. Fig. 8 showed in black and white version.

Animated type of wind speed visualization is important as it portray real time speed. It is useful for example in hurricane or tornado which speed can maximize over 483 kph (300 mph) but different with hurricanes which rarely produces even the speeds over 322 kph (200 mph) (Hurricanes: Science and Society).

V. CONCLUSIONS

Visualization methods are far realistic in the terms visualizing meteorological data into the state of collecting the data. Meteorological factors are basically far more related to each other in order to make an accurate model. Meteorological data is a challenging process to be visualized because of the inherited dimensionality. Visualization technique which provides high quality graphics with no loss of useful information, support large variety of data input and dimension, enable processing large datasets. With the help of the techniques of visualization meteorological data can be visualized using the multidimensional data visualization technique. Both static and animated visualization has been emphasized throughout the paper. A complex problem using the 2D/3D data set can be visualized by using graphics and multidimensional technique.

VI. RECOMMENDATION

For more studies on the application of static and animated visualization application in meteorology, several recommendations are made:

The advantages and disadvantages for both type of visualization

Tools to measure big amount of data over short period time and progression in the current year

Cognitive effect for static and animated visualization focusing in meteorology

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