The Analysis of the Haines Index Climatology for the Eastern United States, Alaska, Hawaii, and Puerto Rico

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1. INTRODUCTION

Since the Haines Index (HI) was introduced in 1988 (Haines, 1988), it has been used as a tool by fire managers in their decision-making to assess fire risk. The HI is a lower atmospheric severity index for wildland fire severity (growth potential) based upon environmental lapse rates and moisture (Haines 1988). Index values of 1, 2, and 3 for stability and moisture are summed to get a value from 2 to 6. Each of the two factors, stability and moisture, could influence the fire growth.

The Index values range from 2 to 6 depending on weather conditions. The higher value represents conditions more conducive to fire growth. Atmospheric stability and lack of moisture can promote the spread and intensity of fires by increasing the height and strength of the smoke columns, spotting, fire whirls and dust devils, and other convective or uplifting winds at the surface that affect fire behavior (Werth and Ochoa 1993).

The HI is an easy way to combine two important variables into one simple value as a measure of atmospheric stability and dry air. However, the HI has little value for nighttime operations because the reports are only valid around the time of the upper air soundings, (0000 UTC and 1200 UTC). It does not take into account fuel moisture and is not a component of the National Fire Rating System or the Fire Behavior Prediction System.

Several studies have explored the properties of the Haines Index. Brotak (1993) considered the use of upper air data from 1200 UTC for computing the Index. Results showed a shift from Index values of 6 (high fire risk) to 5 (moderate risk) in all elevations and were primarily due to a decrease in the stability component of the index. Typically morning soundings exhibit a neutral or stable lapse rate with an inversion.

Werth and Werth (1998) expanded the original climatolology of the Haines Index (1988) for the western United States. It established a more detailed high-elevation HI based on upper air data. The frequency of high index values and seasonal variations in the index were also investigated in this region. Their results indicated using 1200 UTC observations instead of 0000 UTC does not change the frequency of "Haines 5 days" at most locations (days when the Haines Index is 5), but decreases in frequency of Haines 6 days.

In the present study, Haines Index climatology for the eastern United States, Alaska, Hawaii, and Puerto Rico is being prepared for low, mid, and high elevations. Alaska, Hawaii, and Puerto Rico are being examined because these states have not been included in previous studies. Preliminary HI parameters, averages, and relevant statistics were obtained using C++ and spreadsheet analysis and histograms, bar graphs, and other methods.

The climatology will include the frequency of occurrence of HI values (2 to 6) and examine the spatial and temporal patterns displayed by the relative frequencies of the HI values. The frequency analysis will also help determine whether the 1200 UTC values can provide advance notice or better prediction and discrimination of pending fire risk than the 0000 UTC values.

The Index will help provide aid to fire mangers in their decision-making in assessing the growth of wildland fires. The proposed study is aimed at increasing understanding of the effects of meso- and large-scale meteorological processes on wildland fire severity and atmospheric interactions. For this paper, two sites, were analyzed for preliminary analysis: Bismarck, ND (KBIS) and Jackson, MS (KJAN).

2. BACKGROUND – FIRE CLIMATOLOGY

The Haines Index will necessarily vary between climate regions studied. Most of the United States is located between 30°N and 50°N, a region commonly referred to as the middle latitudes (Ahrens 1994). Most of the United States also lies between 75°W and 125°W longitude. Temperature differences along the coastal margins are due in part to the unequal heating and cooling of land and water, ocean currents, and upwelling. Air flowing inland from the Pacific Ocean becomes hot and dry over land.

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The climate in the west is generally hot and dry with high temperatures and low dew points, which produce low relative humidity. Air flowing inland from the Gulf of Mexico creates a hot and muggy air mass once it moves into the central United States. The climate in the south and southeastern areas is generally hot and humid. High temperatures dominate with high dew points and relative humidity. There are obvious differences in seasonal precipitation among the west coast, central plains, and east coast as well. Precipitation in the west coast is a maximum in winter, for the central plains the summer, and in the east coast its fairly uniform throughout the year (Ahrens, 1994).

The Great Plains has a distinct summer and winter season because of it's humid subtropical climate. Few fires become serious fire hazards because fuels are generally too light and sparse except in timbered areas. Temperatures in this region vary greatly due to the frequent presence of cold and dry air masses in the winter, and the occasional presence of warm and dry and warm and moist air masses in summer, more prevalent in the southern portion.

Precipitation in the region is light to moderate. One reason for low precipitation in this region is that the western portion of the plains located in the Rocky Mountain rain shadow. Precipitation is at a maximum in the summertime, generally in the form of convective showers and frequent thunderstorms. The most critical fire-weather periods in this region are associated with the Pacific High synoptic type with the highest fire danger generally occurring during the summer in the western or northwestern portions.

The Chinook type occurs in the western portion of the plains due to the winds blowing down the east slopes of the Rockies extending some distance into the plains. This creates extreme fire danger in the spring and fall due to mild temperatures and low humidities even when Chinook occurrence in winter may be more frequent (Schroeder, Buck 1970).

The Southern United States has a distinct summer and winter season because of it's humid subtropical climate. Warm and humid summers are prevalent because the region is almost continually under the influence of Maritime Tropical air. Temperatures generally fluctuate during winter due to the passage of cold fronts. The Bermuda High type is most important in the southern portion of the region and can produce high fire danger east of the Rockies.

Pines along the coastal plains, hardwoods in bays and bottomlands along stream courses, and hardwoods and mixed conifers in the uplands make up the vegetation in the Southern states (Schroeder, Buck 1970). Flash fuels that are flammable even shortly after rainfall, dominate the region. The topography of the Atlantic and Gulf is low and flat. Moving inland from the Atlantic Coast this region merges with an intermediate Piedmont area. The most critical fire-weather periods in this region are mainly spring and fall. Fires may occur in any month. Extended drought accompanied by low humidities and high temperatures, set the stage for high fire danger. Lighting accounts for only a small number of fires in the region.

3. METHODS

Meteorological and upper air data from the period 1961 to 1990 was obtained from NCDC's CD-ROM (NCDC 1993). The data were downloaded from the CD-ROM (WMO Station Identifier format), placed in individual files according to each station name, and placed in sub-files by year. Data from one to three radiosonde sites are analyzed for each station.

The Skew-T/Hodograph Analysis and Research Program (SHARP), was used to view upper air soundings (SHARP; Hart & Korotky 1991). The program allowed view/retrieval of meteorological data one sounding per analysis. Therefore data were downloaded in ASCII text FSL format and placed in files by each station name and in sub-files by year. Station Identifiers were obtained from NOAA (http://www-frd.fsl.noa.gov/mab/raob.

The Haines Index was then calculated from a lapse rate for the 950 to 850 mb layer and a temperature dewpoint spread at 850 mb for KJAN, which is observed at low elevation. For KBIS the lapse rate was taken from 850 TO 700 mb and a temperature dewpoint spread at 700 mb, which is observed at mid elevation (Haines 1988). The initial temperature and dewpoint at each of the layers above were verified by hand calculations to check the C++ program. Programming included Station Location, Month, Day, Year, UTC, and meteorological data at each pressure level. The Haines Index values for 0000 UTC and 1200 UTC were then placed into a spreadsheet and analyzed to obtain relative frequencies of occurrence. The relative frequency was calculated by dividing the number of occurrences for a particular Haines Index value by the total number of days for which data were available. Maps were then prepared to illustrate the frequency of occurrence spatially and for temporal evaluation.

4. RESULTS

Histograms for the spring (MAM) and summer (JJA) seasons of the relative frequency distribution of HI values were prepared for 0000 UTC and 1200 UTC. For illustration, data for 1961 are used here. The 0000 UTC data for Bismarck, ND (KBIS) during shows a similar pattern of low growth potential for March and low to moderate for April. In May, the growth potential is moderate. A slightly steady shift from low to moderate is noticed during 0000 UTC. For 1200 UTC data, the result show in April a pattern of low to moderate growth potential, but a pattern of low growth is seen mainly through out the season.

The histograms developed for the summer are distinctively different from the spring. Values of the HI were 2 for only 3.2% of cases in the summer. For June (0000 UTC) an increase from 0% (HI=2) to 65.5% (HI=6) is seen. July shows an increase to a maximum of 35.5% at HI=5 and then declines to 32.3% at HI=6. August at 0000 UTC also had a pattern of increase from 0% at HI=2 to a maximum of 60% at HI=6. A pattern of high potential growth is seen through out the summer. The results mentioned above could be caused by summertime atmospheric conditions such as: warm and dry air or warm and moist air masses that are present in the region. Precipitation is also light to moderate.

The spring frequencies for 0000 UTC at KJAN shows a maximum of 64.29% at HI=5 during March followed by 55.17% at HI=6 for May. A uniform pattern of moderate growth potential is shown through out March-May. 1200 UTC shows a slight variation between low to moderate fire growth potential during the season. The results are persistent with the atmospheric conditions, such as: air mass thunderstorms, warm and humid air, which occur during the spring.

The summer pattern for KJAN is different from the spring. Values of the HI were 5 mainly through out the entire summer period. An increase in the HI=5 occurs between June and July with July and August steady at 93.6%. 1200 UTC shows higher percentages than 0000 UTC but both times reflect moderate growth potential during this season. This region generally has warm and humid summers. Maximum temperatures occur around 4pm, which could be one reason for the high frequencies of moderate growth during 1200 UTC.

Clearly the two sites in the study are located in different parts of the country, have different elevation levels, and thus different results. Moderate to high growth potential dominates KBIS region during the summer, while a pattern of moderate growth is present in KBIS during the spring and moderate to high during the summer. Moderate to high growth potential dominates KJAN region during the spring. This region also sees a pattern of moderate to high growth during the summer.

5. ACKNOWLEDGEMENTS

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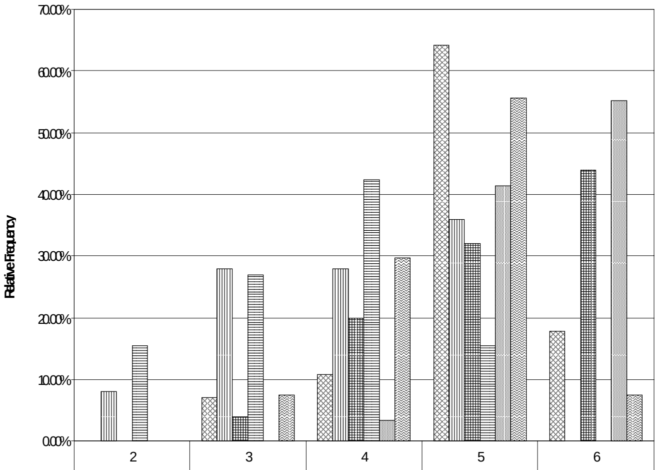
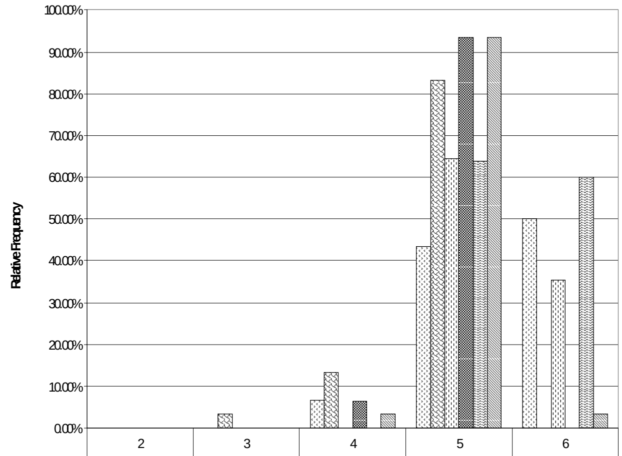
Jackson, MS (KJAN) Spring 1961 (MAM)



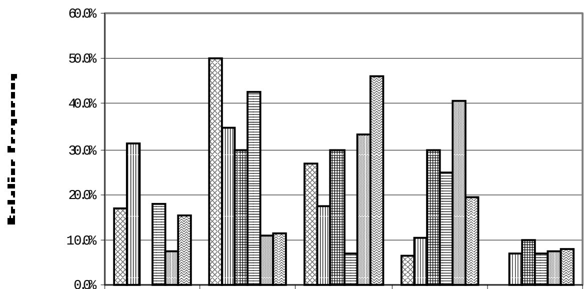
	2	3	4	5	6
March 00Z	0.00%	7.14%	10.71%	64.29%	17.86%
March 12Z	8.00%	28.00%	28.00%	36.00%	0.00%
April 00Z	0.00%	4.00%	20.00%	32.00%	44.00%
April 12Z	15.38%	26.92%	42.31%	15.38%	0.00%
May 00Z	0.00%	0.00%	3.45%	41.38%	55.17%
May 12Z	0.00%	7.41%	29.63%	55.56%	7.41%

Jackson, MS (KJAN) Summer 1961 (JJA)



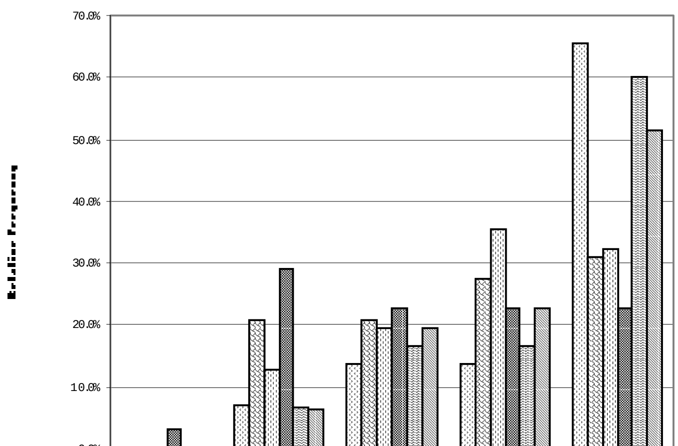
	2	3	4	5	6
June 00 Z	0.00%	0.00%	6.67%	43.33%	50.00%
June 12 Z	0.00%	3.33%	13.33%	83.33%	0.00%
July 00 Z	0.00%	0.00%	0.00%	64.52%	35.48%
July 12 Z	0.00%	0.00%	6.45%	93.55%	0.00%
August 00 Z	0.00%	0.00%	0.00%	64.00%	60.00%
August 12 Z	0.00%	0.00%	3.23%	93.55%	3.23%

Bismarck, ND (KBIS) Spring 1961 (MAM)



	2	3	4	5	6
March 00Z	16.7%	50.0%	26.7%	6.7%	0.0%
March 12Z	31.0%	34.5%	17.2%	10.3%	6.9%
April 00Z	0.0%	30.0%	30.0%	30.0%	10.0%
April 12Z	17.9%	42.9%	7.1%	25.0%	7.1%
May 00Z	7.4%	11.1%	33.3%	40.7%	7.4%
May 12Z	15.4%	11.5%	46.2%	19.2%	7.7%

Bismarck, ND (KBIS) Summer 1961 (JJA)



	2	3	4	5	6
June 00Z	0.0%	6.9%	13.8%	13.8%	65.5%
June 12Z	0.0%	20.7%	20.7%	27.6%	31.0%
July 00Z	0.0%	12.9%	19.4%	35.5%	32.3%
July 12Z	3.2%	29.0%	22.6%	22.6%	22.6%
August 00Z	0.0%	6.7%	16.7%	16.7%	60.0%
August 12Z	0.0%	6.5%	19.4%	22.6%	51.6%