Meteorological Implications of the First Voyage of Christopher Columbus

Abstract

The log of the first voyage of Christopher Columbus to the New World provides valuable information on the meteorological conditions of September 1492. Comparison and analysis of the descriptive accounts of weather made by Columbus and his pilots to other available Columbian and modern data leads to two distinct perspectives on the Columbian voyage: an examination of the frequency of "calm" events, and an analysis of the lack of tropical storm activity. The major conclusions of the first portion of the study include: 1) The Columbian pilots' descriptions of "calms" related to travel slower than travel occurring during other portions of the voyage. That rate of travel compares favorably to calm winds and an oceanic current of 0.4 knots, a value close to modern-day values; 2) The frequency of "calm" events experienced by Christopher Columbus in 1492 is significantly higher than the most liberal estimates of calms in the North Atlantic over the last 100 years; and 3) The locations of the Columbian calms are generally in the same region currently experiencing the highest frequency of calms. The main finding of the second portion of the study is that, based on historical hurricane records from 1886 to 1989, the center of a hurricane would have passed within 100 km of Columbus only once in the past 104 years. Inclusion of tropical storms increases this number to four out of 104 years. Therefore, while Columbus may indeed have been fortunate to have avoided severe weather during his voyage, the odds decidedly were in his favor. This Columbian "weather luck" was due to a combination of 1) encountering abnormally strong anticyclonic flow over the eastern North Atlantic, 2) starting late enough in the hurricane season to significantly decrease the probability of experiencing a hurricane, and 3) taking a north and easterly voyage, thereby avoiding the area of maximum hurricane occurrence.

1. Introduction

Two factors suggest a reexamination from a meteorological viewpoint of one of the most famous voyages in history, that of Christopher Columbus. First, recent studies in climate (e.g., Rind et al. 1989) suggest future changes in climate variability may occur due to such forcing mechanisms as enhanced atmospheric carbon dioxide. Knowledge of past climate variability such as derived from Columbus's observations may be of use in evaluating the magnitude of the sensitivity of model parameterizations (Mitchell 1990) and aid in establishing a scale of the magnitude of past climate variability. Climate reconstruction based on historical records has been proposed and accomplished in past studies. Burt (1990), for example, in his unsuccessful search for the early Manila Galleon log books, suggested that study of those logs would facilitate analyses of major El Niño events. In a more positive light, studies of climate and history (e.g., Landsberg 1980; Landsberg and Douglas 1984; Oliver and Kington 1970; Stommel and Stommel 1983; Wang and Zhao 1981) have shown substantial variability in past climate. Investigation of other specific historical events may also be used to determine the degree of variability in past climate and aid in the establishment of a more complete historical climatology database.

Second, weather has provided the stimulus for renewed interest in reconstructing the track of the first voyage of Columbus (Kelley 1985; Marden 1986; Richardson and Goldsmith 1987). Recent reconstructions of the Columbus voyage have used modern wind speeds and ocean currents from U.S. Navy pilot charts as proxies for the winds and currents experienced by the Columbus ships of 1492. The researchers justify the use of modern winds by noting that 1) "In the physiography of the earth, 1492 is yesterday. Currents and winds cannot have changed, on the average, very much in that instant of geologic time" (Marden 1986, p. 576), and 2) "We assumed that winds and currents encountered by Columbus in September and October of 1492 did not differ appreciably from historical compilations for September and October during the last 50 years" (Richardson and Goldsmith 1987, p. 5). The validity of these assumptions can be tested.

One of the critical meteorological features associated with the first Columbus voyage was the lack of adverse weather. Although Columbus undertook his first voyage during what is now considered the height of the Atlantic hurricane season, he apparently did not encounter any significantly adverse weather. Ludlum (1963), in his classic reconstruction of North Atlantic hurricanes, noted that "the outstanding meteorological fact of the First Voyage is simply that no hurricanes or severe storms were encountered in the West Indies despite the fact that the fleet of three small vessels traversed an area of tropical storm activity at the season of their most frequent occurrence" (Ludlum...
1963, p. 1). The implication is that Columbus, had he known the climatology of the area, would have considered himself lucky that he did not encounter an Atlantic hurricane. But is this true? Was Columbus “lucky” in that the North Atlantic weather of September 1492 was unusually calm, or was perhaps the climate regime of the late 15th century less prone to the development of tropical cyclones? Study of this question begins with an examination of the “calms” experienced by Columbus.

2. The presence of anticyclones

Description and notations of winds experienced by Columbus are based on the translations and analyses of the Columbus journal (Fuson 1987; Jane 1930; Morison 1942; Nunn 1924). The most direct record we have of the strength of Columbian winds is from the observations made by the pilots and noted into the ship’s log. These observations included notations on the color of the water and presence of certain types of birds and fish, as well as subjective impressions of winds, currents, and weather. Study of these observations reveals that on the outward journey of 36 days to the New World, there were 16 separate references to wind conditions. Generally, these references subjectively discussed the relative strength of the wind. Eleven separate days of calm or near-calm conditions were cited in the journal (Fig. 1), four days of “mild” or “soft” breezes, and one occurrence of “freshened” winds. As no other measures of wind are available, this study will concentrate on extrapolating meteorological information from these observations. This is achieved by linking these subjective observations to other data associated with the voyage, in particular, the relative speed of the travel. As Burt (1990) noted, the speed of the voyage can be indicative of weather conditions: “A slow trip westward across the Pacific [by the Manila Galleons] could indicate weakening of the trade winds and even reversing of their direction in the western Pacific.”

Measurement of the ship’s speed was, and still is, a critical factor in navigation. It is probable that Columbus’ pilots made use of a simple “Dutchman’s Log” method in determining ship speed. Each half hour, as measured by a sandglass, the pilot threw a woodchip into the water and timed its passing. Although exact procedures used by Columbus are not known, modern methods that do not make use of longitude determination measure the time and distance the ship takes to sail a set distance away from the chip (Greenwald 1989). The speed \( V \) can then be computed following:

\[
V \text{(in knots)} = \frac{(1 \text{ n mi})(3600 \text{ s})}{(1 \text{ h})(6080 \text{ ft})} \times D
\]

where \( D \) is the set distance (in feet) and \( t \) is the elapsed time (in seconds). This speed was multiplied by the time interval since the last measurement, and the corresponding distance was then entered on a plotting board. Columbus did not use nautical miles as his unit of measurement. He recorded distances...
in units of “leagues,” but the exact value of a Columbian league is still not fully accepted. For example, Marden’s (1986, p. 577) calculations are based on 1 league = 2.82 modern nautical miles. Conversely, Kelley (1985, p. 91) reconstructs the voyage using a Columbian 5000-palm mile of 4 leagues equating 4060 ft, so that 1 league = 2.67 modern nautical miles.

Regardless of the exact distance of a Columbian league, the unit of measure can provide information of the accuracy of the pilots’ meteorological descriptions. The mean distance traveled on days associated with “calm” conditions is 15 “Columbian” leagues, while on all other days the mean distance traveled is 39 “Columbian” leagues. A Student’s t-test comparison indicates that there is a statistically significant (at the 99.99% confidence level) difference between those two datasets. This suggests that, while Columbian observations were of sufficient quality to be able to statistically differentiate between travel during these “calm” measurements and travel at other times of the voyage. The assumption is therefore made for this study that Columbian observations of calm events are usable for research into the meteorological conditions experienced in 1492.

If Columbian pilots were accurate in their meteorological descriptions of “calms,” and the relativistic movement of the ships and other effects are considered negligible, then the 15.2 leagues Columbus’ vessels traveled under those conditions should relate primarily to the effect of the speed of the current. Estimates of modern current speeds for the midoceanic portion of the Columbus track (derived from U.S. Navy pilot charts) average around 0.4 kt (−0.2 m s⁻¹) (Kelley 1985; Marden 1986; Richardson and Goldsmith 1987). If the 15.2-league travel distance under “calm” conditions is taken to have occurred over the 24-hour day, the speed of travel under “calm” conditions becomes 0.6 leagues per hour. An estimate of that current speed can be made given modern estimates of Columbian leagues. If Kelley’s (1985) value of 4060 English feet (1.237 km) is accepted as equivalent to 1 Columbian league, the speed of travel under “calm” conditions becomes 0.4 kt (−0.2 m s⁻¹). If Marden’s (1986) value of 4286 English feet (km) is accepted as equivalent to 1 Columbian league, the speed of travel under “calm” conditions becomes 0.42 kt. As stated above, both these estimates compare favorably with values for modern ocean currents for the area.

A corollary study (Cerveny, in review) addresses a second question involving the frequency of calms along the track of first voyage. As stated above, existing log data reveal that Columbian ships experienced calm conditions on 11 out of 36 days associated with the voyage, or sailed under calm conditions for a total of about 30% of the time. Using a dataset of 100 years of available pilot charts of the North Atlantic, the variations in the 20th century pilot data were compared to the Columbian data. The average frequency of calms between 1892 and 1939 was found to be on the order of 10%–15%, while, due to changes in observation practices, the frequency of calms between 1940 and present is on the order of 3%–5%. That study concludes that, even with the most liberal estimates of frequency of calms in the 20th century, Columbus was subjected to more than twice the number of calms than occur in the region presently.

The geographical location of calms is a third aspect of the Columbian voyage that can be addressed with the available data. Latitudinally, analysis of the 5° x 5° boxes associated with the 1989 pilot chart (Defense Mapping Agency 1989) suggests that track associated with the Columbian voyage is currently the latitude experiencing the greatest number of calms in the North Atlantic Ocean. Early compilations of ship reports across the Atlantic show that the average frequency of calms in the region traveled by Columbus is between 1% and 5%, with the areas north and south of the Columbian track experiencing less than 1% frequency of calms (McDonald 1938). Because of this, the higher number of calms in 1492 is probably not the result of a northward or southward movement of the subtropical Bermuda High, but instead may be associated with an intensification of the high pressure in 1492 as compared to modern day.

Longitudinally, as seen in Fig. 1, Columbus encountered calms in three distinct regions of the North Atlantic. One was near the Canary Islands, where at the start of his voyage he encountered three consecutive days of calms. The second set of calm conditions was experienced from the 14th through 18th days of the voyage, between about 40° and 45°W. The third and final sequence of calms was identified between 48° and 52°W, from the 23rd through 27th days of the voyage.

These locations compare favorably with the same area along the Columbus track that currently experiences the greatest frequency of calms. A composite of the standardized frequency of calms for 11 pilot charts from 1892 to 1989 shows that the greatest tendency for calm events along the path of the Columbian voyage occurs between 20° and 30°W and between 35° and 60°W (Fig. 2).

To summarize these findings:

1) The Columbian pilots’ descriptions of calms related to significantly slower travel than travel occurring during other portions of the voyage. That rate of travel compares favorably to the rate of travel associ-
ated with an oceanic current of 0.4 kt, a value close to modern-day values.

2) The frequency of calm events experienced by Christopher Columbus in 1492 is significantly higher than the most liberal estimates of calms in the North Atlantic over the last 100 years.

3) The locations of the Columbian calms are generally in the same region currently experiencing the highest frequency of calms.

3. The absence of hurricanes

While the Diario of Columbus can be evaluated with regard to the changes in fair weather resulting from subtropical high pressure, study of the “other side of the coin,” the presence or absence of tropical cyclones, provides additional information on the weather of 1492. Since it is difficult, if not impossible, to reconstruct an accurate hurricane climatology during the period of Columbus (see, for example, Caviedes 1991), this examination is based upon a climatological study of known hurricanes and tropical storms between 1886 and 1989. This dataset, which contains information on the positions and intensities of the known storms, was prepared by the National Hurricane Center and is available from the National Climatic Data Center (NCDC 1990). It includes information on 875 storms.

This portion of the study uses a computer reconstruction of the First Voyage labeled “Case 06a” by Goldsmith and Richardson (1987). This simulation uses the Columbus log data from Marden with rhumbline positioning. Positions were computed every 30 min, with no day lengthening considered. A field of magnetic variation was computed using an algorithm that minimizes the curvature of the fitted surface. The average autumnal wind and current fields are based on modern data of those variables with a leeway wind factor of 0.014. The landfall computed from this reconstruction is Watling Island.

A search procedure was constructed to compare the dates and locations of Columbus’ fleet with the tracks of the storms in the dataset. Any systems that dissipated prior to Columbus’ departure or originated after his landfall were eliminated from further consideration. The remaining storms were inspected to determine those tropical cyclones that moved within a specified distance of the positions of the Columbian fleet. This technique produced lists of storms that Columbus might have encountered if he had made his voyage between 1886 and 1989. The search radii were varied to determine which storms would have passed very close to his ships and which storms would have had a more peripheral effect on his voyage.

The initial search was conducted for a 2° latitude x 2° longitude box centered on the position of the Columbian fleet. Four tropical cyclones were identified during this search. Three of these storms occurred between 1900 and 1906, while the fourth formed in 1949. Of these four tropical cyclones, only one is classified as reaching hurricane strength. In 1900, a minimal hurricane moving through the eastern North Atlantic passed near Columbus’ positions in the middle of September. In 1905, a strong tropical storm passed close to the position of the Columbian fleet in October near the date of the landfall. A tropical storm in 1906 that was recurving in the eastern North Atlantic moved near the vicinity of Columbus and his crew near the end of September. Finally, in 1949, a weak tropical storm would have passed near Columbus’ location in the latter part of September.

It is clear from this analysis that, if modern hurricane frequencies correspond to those of 1492, the chances of the Columbian fleet receiving a direct hit from a hurricane would have been relatively small. The center of a hurricane would have passed within 100 km of Columbus only once out of the past 104 years. Inclusion of tropical storms only increases this number to four out of 104 years.

Initially, this may seem surprising, particularly with regard to Ludlum’s remark suggesting that the most extraordinary feature of the First Voyage was the lack of an encounter with a tropical cyclone. However, analysis of the timing and path of his voyage with regard to hurricane climatology may suggest an explanation. Columbus left the Canary Islands after the peak of the Atlantic hurricane season that normally occurs in early September (Neumann et al. 1981). During the early portion of his voyage, his ships were sufficiently north and east of the average hurricane track to have avoided all storms except those that...
might have recurved in the eastern Atlantic Ocean. During the middle of his voyage, proximity to the subtropical high would have steered most storms away from his path (particularly if, as suggested here, the subtropical high was stronger during 1492 than normally occurs today). There was some slight increase in the possibility of an encounter with a tropical storm as he approached the Caribbean Sea, but Columbus made landfall near the end of the active portion of the Atlantic hurricane season.

The search procedures were then expanded to include boxes of 5° latitude x 5° longitude box and of 10° latitude x 10° longitude. This would identify the probability that Columbus might have encountered the peripheral effects of tropical cyclones. Increasing the dimensions of the search area to 5° x 5° resulted only in the selection of three additional storms. Two of these systems were hurricanes, and one was a tropical storm. When the dimensions of the search were increased to 10° x 10°, an additional 20 storms were identified. Twelve of these systems were hurricanes and eight were tropical storms. Many of these tropical cyclones were found near the edges of the geographical search regions.

To summarize these findings:

1) Using modern (1886–1989) tropical cyclone tracks, Columbus might have been expected to encounter the center, and the most intense portion, of a tropical storm in fewer than four times out of a possible 875 storms. This relates to a time period of 104 years, so that Columbian odds of encountering a tropical cyclone in any given year (if modern frequencies are used) were 1:26.

2) This number drops to 1:104 if only those storms of hurricane intensity are considered. In other words, based on modern hurricane frequencies, Columbus would have expected a hurricane to intersect with his route at most only once every century.

4. Conclusions

These findings allow us to draw tentative conclusions regarding the weather of September 1492. From the findings involving Columbian “calms,” the similarity in the locations of calm events experienced by Columbus and his crew to the area presently experiencing the greatest frequency of calms suggests that the relative location of the subtropical high pressure system is approximately the same for two time periods. It is reasonable to assume that changes in frequency of calm events therefore relates to changes in intensity rather than location of the subtropical high. An increase in frequency of “calm” events in 1492 attests that the subtropical high was stronger in 1492 than the present-day average conditions in the North Atlantic would indicate. So, while available data imply that the weather of 1492 was abnormal, the question remains as to whether this abnormality was short term or an attribute of a distinctly different climate regime.

Scarcity of data obviously limits the degree to which this question can be answered, but some general conjectures can be drawn. These conjectures relate to the ocean currents of 1492 and their relation to long-term climate. Researchers have noted that, because of the lack of oceanic data, the daily or seasonal variability in ocean circulation is far more difficult to determine than corresponding variability in the atmosphere (Washington and Parkinson 1986). Yet ocean-modeling studies (Meehl et al. 1982) have shown the large impact of wind stress on ocean currents. According to these studies, halving the wind stress decreases both the zonal and meridional components of ocean currents up to 50% in the tropical latitudes. This implies that long-term changes in surface winds over the North Atlantic should be evidenced in analogous changes in ocean currents.

If we assume that travel during Columbian “calms” was due primarily to ocean currents, it is evident that the very close correspondence between the ocean currents of 1492 derived from the Columbus data and the ocean currents of modern data would signify that the long-term surface wind pattern of 1492 was not significantly different than that of modern day. The hypothesized intensification of the North Atlantic subtropical high would consequentially be associated with a short-term change rather than be an attribute of a distinctly different climate regime.

The implications of these conjectures are that 1) there was variability in the strength of the subtropical high in the North Atlantic of 1492, and 2) although, with regard to climate “averages,” modern-day estimates of wind speed could be used as reasonable proxies for conditions in the 15th century, a high probability exists that the weather of 1492 was under the influence of abnormally strong North Atlantic subtropical high pressure in relation to the climate of the late 15th century. A 16th century historian, Peter Martyr of Angleria, makes a telling reference to the lack of storms in the West Indies during the first decade in exploration (Arber 1885): “The same yeare [1495?] in the mooneth of June, they saye there rose suche a boystrous tempeste of wynde from the sowtheaste, as hath not lyghtly ben harte.”

That this anomaly did not continue is evident in Ludlum’s (1963) reconstruction of early American hurricanes, in which he notes that Spanish expeditions in the 16th century did encounter many hurricanes (notably in mid-16th century). Caviedes’ study of the
historical data record indicates minor surges in the number of hurricanes around 1530, 1550, and 1570, which he says correspond to ENSO events in the Pacific (Caviedes 1991). However, the second portion of our study suggests the probability of the Columbian fleet encountering a hurricane was actually quite low, even without considering the apparent lack of storms at that time.

Examination of the historical hurricane record from 1886 to 1989 indicates that only one hurricane of the last century, and only three additional tropical storms, pass within a 2° x 2° box enclosing the track of Columbus at the time of the year in which he made the voyage. This relates to a time period of 104 years, so that odds of the Columbian fleet encountering a tropical cyclone in any given year (if modern frequencies are used) were 1:26, while the odds drop to less than one per century if only those storms of hurricane intensity are considered. These low probabilities are most likely the result of the two considerations: 1) Columbus reached the West Indies sufficiently late in the season to substantially lower the probability of encountering a hurricane, and 2) the Columbian fleet made a sufficiently north and easterly voyage as to miss the major development region of hurricanes and tropical storms.

This research has examined the weather of 1492 as can be cautiously reconstructed from the Columbus Diario. Ludlum (1963) noted "the outstanding meteorological fact of the First Voyage is simply that no hurricanes or severe storms were encountered [by the Columbian fleet] in the West Indies . . . ." This study suggests that while Columbus may have been climatologically fortunate to have avoided an encounter with a hurricane, the odds were decidedly in his favor. This famed Columbian "weather luck" was most probably a combination of 1) encountering strong anticyclonic flow over the eastern North Atlantic, which was the result of a short-term climate anomaly, 2) arriving late enough in the year at the West Indies to have missed the height of the hurricane season, and 3) having made a sufficiently north and easterly voyage to have avoided the normal region experiencing Atlantic hurricanes.

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