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REVIEW ARTICLE

Forensic Meteorology- Reconstructing the Weather: A Review

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Abstract:

Forensic Meteorology is the science of using historic weather records, atmospheric data, eyewitness accounts, and re-enactment simulations to determine the weather conditions at a specific time and location for litigation purposes. Forensic meteorologists frequently visit the scene of the accident or crime to look at the terrain and conditions present. A Forensic Meteorologist could be called to corroborate or disprove an alibi, to supply context for an accident, or to work out if the conditions could have reasonably been anticipated or were an unexpected event. They may be called to provide context for disputes that arise from weather-related events; either between private parties, or in validating insurance claims, in vehicle accidents, agricultural disputes, weather modification, building collapses, or in something as simple as people slipping and falling.

Keywords: Forensic science; Forensic meteorology; Forensic climatology; Forensic meteorologist.

Introduction:

Forensic meteorology is scientific study of weather, applied to the method of reconstructing weather events for a particular time and site. This is done by acquiring and analysing local weather reports such as surface observations, radar and satellite images, other data, and eyewitness accounts.[1,2] Forensic meteorology is most often used in court cases, including insurance disputes, personal injury cases, and murder investigations.[3,4] This is most often the case when weather conditions were a possible factor, as in fall downs after snow and ice, wind, flooding, after aviation and nautical accidents, etc. With increasing losses from severe weather in recent years, the demand for forensic meteorological services has also grown.[4,5] And many forensic meteorologists are certified by the American Meteorological Society (AMS)'s rigorous Certified Consulting Meteorologist (CCM) program.[6,7]

Review:

Although the term “forensic meteorology" (or forensic climatology) has only been used for the past 30 years or so, the practice of applying weather and related knowledge to legal matters is nothing new. In the March 1900 issue of Monthly Weather Review, Professor H.J. Cox, who at the time headed-up the U.S. Weather Bureau's Chicago office, provided the following summary of his experiences in the courtroom that since the opening of the present term of court, last fall, he has been in court thirty-three times to testify as to the condition of the weather at a particular time and as to what bearing it might have on the case at issue. In addition to these thirty-three cases many cases are settled out of court on the records of the weather department. Such cases are principally damage suits arising from the shipment of perishable goods. Although the National Weather Service (NWS) still provides forensic services to other government agencies involved in the investigation and litigation of weather-related accidents (such as the National Transportation Safety Board), weather service employees generally are prohibited from testifying in court, except in cases involving the federal government or the role of providing expert witness testimony for cases.[8,9]

Conrad B. Gosset, MS (Meteor), a consulting meteorologist felt that meteorologists who were provide these services should have a professional name. He introduced the phrase “Forensic Meteorologist” within the mid-1960s, and discussed in his unpublished keynote address at the primary Conference on Forensic Meteorology, November 5–6, 1976, in New Orleans in conjunction with the annual conference of the American Meteorological Society.[9] The first use of the term by The New York Times was in reference to Mr. Gosset's work in a 1982 article.[9]

Essentially, a forensic meteorologist may be a quite weather detective. They reconstruct events associated with weather, often providing consulting and witness testimony to legal firms and insurance companies, consistent with its GOV's website. The job of this type of “weather detective” is to assist provide information regarding the precise role that weather (cold, snow, wind, rain or other types) may have played in a fire or accident that has caused damage to people or property. Sometimes accidents like these have legal and insurance repercussions, and therefore the forensic meteorologist is named upon to offer their insights in court or in other settings.

A successful forensic meteorologist needs to have a blend of technical expertise and the ability to present the facts of a case effectively, especially when serving as an expert witness. This calls for what Haggard referred to as jury presence. “You can't be the world's greatest meteorologist and a bumbling idiot. It makes sense to be a pretty good meteorologist and a person that the jury believes. Jury credibility is essential.”[10,11]

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Forensic meteorology requires the utilization of the many different sorts of tools and instruments additionally to solid reasoning in math and science. Someone working within the field will likely make use of satellite images, computer weather modelling and various eyewitness reports as they reconstruct a timeline surrounding a weather event. A forensic meteorologist will often be called to a scene within the wake of a serious storm or weather catastrophe. When such a serious storm hits (hurricane, flood or tornado), sometimes local weather stations aren't ready to function, which is when a meteorologist must rely more on modelling and prediction skills. In addition to being present after major events, the talents of forensic meteorology could be useful in determining the explanation for an accident involving ice or lightning hazards.

A forensic meteorologist must have a firm grounding in atmospheric science. There are bachelor's degree within the field, though many who continue to review meteorology at the graduate level begin with a bachelors during a related field such as geoscience, physics, chemistry or math. Really any of these fields would be a useful preparation for becoming a meteorologist, and can likely be studied at advanced levels in an atmospheric science degree. Computer programming is another important skill during this field. One of the more important resources for professional development within the field is that the American Meteorological Society, whose career centre offers many information about different careers in meteorology as well as insight into a number of the settings where meteorologists may apply their knowledge and skills, including private companies, government offices or universities.[12,13]

Often, the meteorologist's analysis of a particular case is hindered by the fact that the closest weather station to the site in question can be some distance away. “That's when you have to dig into the many layers of data that are available to the forensic meteorologist,” Falconer said. He credits the NWS modernization program during the 1990s with increasing the value of the forensic meteorologist as someone who knows the capabilities of new equipment and where to find ancillary information regarding a particular case. Regardless of the source of the data, it is the job of the forensic meteorologist to piece together as many elements of the weather puzzle as possible and determine what actually happened to a reasonable degree of certainty. “The reason why forensic meteorologists are so important to attorneys in a litigation contest is that you cannot really accept the anecdotal evidence of what the weather was like on a particular date and location,” said Roger Haerr, a partner in the real estate litigation group of Luce, Forward, Hamilton & Scripps LLP of San Diego. “Forensic meteorologists can really make the difference between winning and losing to the extent that the case depends on some influence of the weather.”[13]

Described as a mixture of science, art and interpretation, forensic meteorology mirrors the work that detectives do to unravel crimes. Cases may involve whether lightning sparked a fireplace or, if someone slips and falls, whether ice on a property was responsible. Data comes from various sources, including observations, weather stations at airports, Doppler radar and satellite imagery, National Weather Service bulletins, and even tidal gages. Forensic meteorologists can also take their own measurements, like wind velocity. Cases are mainly site-specific, and far of the problem-solving involves knowing what synoptic, or generalized, data is required to reconstruct the micrometeorology at a specific location.

A lot of what we rely on is experience, but we'd like tools of the industry, like Doppler radar and good observations" to unravel mysteries associated with weather, Lombardo says. He recounts one among his cases during which a crane collapsed near a building, injuring the operator. Lombardo visited the location on each day that had similar conditions as when the accident occurred, and on noticing that Grus was positioned near a nine-meter wall, wondered if that had influenced the site's wind velocity. He measured the wind speed using an anemometer, noting that the wind intersected the wall at a 70 to 80 degree angle. By calculating simple vectors, he discovered that the wind speed near Grus was around 29 to 48 kilometers per hour, right at the sting of what Grus could withstand. It was a function of the wind converging on the wall, which increased the wind pressure on Grus, causing it to collapse."[13-15]

Sometimes, data that's needed to decipher how atmospheric conditions affected a specific location and case isn't available. Stephen Wistar, a forensic meteorologist with Accu Weather, consulted on many cases concerning Hurricane Katrina. Most of his investigations centered on insurance claims about whether wind or storm surge caused property damage He utilized a massive computer model called "ADvanced CIRCulation" (ADCIRC), which predicts tidal and storm surge elevations and velocities over large areas. Combined with information he retrieved from Doppler radar sites outside of latest Orleans, and on-site investigations he conducted himself, he was ready to reconstruct time lines of property damage and state which hit property first-the wind or the water.

In his Katrina inquiries, Wistar also discovered that "trees were very helpful" in solving cases. In areas of mobility, where complete neighbourhoods were torn apart, he often examined tree damage for clues about what caused property destruction. He knew the direction of the wind at various points within the storm, both before and after the storm surge, and thus could determine which direction trees would have fallen at those same points. By noting fallen tree locations and directions, he determined time lines for property devastation, even when there have been no structures left standing.

" Another concern is that the uptick in weather and related events occurring on a planet-wide basis, like El Niño and La Niña. Generally, forensic meteorologists' examinations are limited to a specific site. "If climate change continues to occur, however, and we see more worldwide events in increasing frequency, will that change how we look at local events? It may," ponders Lombardo. He cites a worldwide weather phenomenon, called atmospheric blocking, as an example of a planet-wide occurrence that's has already affected his forensic micrometeorology endeavours. Atmospheric blocking obstructs winds that come across the Pacific and forces them north into Alaska, Siberia and the North Pole. The winds then head south, "creating a pool of cold Arctic air that moves and provides a source for ice storms to develop," he says. In the past two years, up and down the eastern seaboard, atmospheric blocking has directly led to snowfall in areas where

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heavy snow is rare, and consequently, "hundreds of slip-and-fall cases" have come across Lombardo's desk. "Atmospheric blocking leads to localized storms that produce the conditions that are favourable to generating future forensic work," he says[15]. As Wistar notes, more people have migrated to regions on the earth "where the weather tends to be more dangerous," like the southern U.S. With more people in harm's way, there'll undoubtedly be more legal, insurance and engineering cases during which forensic meteorologists' expert contributions are going to be vital.

Can a person with a degree in Meteorology do past weather reports? Yes and no. There is no legal certification required for a Meteorologist to testify in court; however, the Meteorologist must demonstrate that he/she has the professional experience and academic requirements to render such expert opinions. In order to make sure the general public receives qualified and reliable experts within the field of Meteorology, the American Meteorological Society (AMS) offers a licensed Consulting Meteorologist (CCM) certification. To earn the CCM credential, a Meteorologist must pass a stringent written and oral, demonstrate a broad background in Meteorology alongside detailed knowledge during a particular field of specialization, show exemplary qualities of character, and devotion to high professional standards.

With the recognition of the forensic sciences on the increase, an interest in learning more about forensic meteorology. Unlike a number of the opposite forensic sciences, forensic meteorology is a smaller amount concerned with utilizing research project within the solving of crimes than it's with utilizing such research to help settle property loss and insurance claims.[15]

Though this is often an unlicensed profession, most who testify voluntarily undergo certification from their professional organisation. The other requirement is that meteorology must be relevant to the case at hand, that the analysis is predicated on reality, their analysis uses logical processes, which the expert remains objective. According to an interview with Dr. Elizabeth Austin, a Forensic Meteorologist, when temperatures rise, criminal activity increases. Austin goes on to mention that there is significantly higher crime rates in cities when the temperatures are appreciably above average. She noticed that extreme rainfall results in increased conflict among people, and developing countries are more vulnerable to conflict and wars when agriculture is threatened by drought conditions and hot temperatures. When solving a crime, the temperature and humidity conditions around where the body was found are most vital for timing a murder.[15,16]

Can Forensic Meteorologists Assist DNA Analysis? In her interview, Dr. Austin tells of a case that she worked on where weather helped to nab the criminal after a criminal offense was committed. While investigators continually searched for ways to collect the perpetrator's DNA, he refused to drink from cups or lick an envelope that they had given him. Luckily for investigators, it had just rained on the day that they were tailing him, so when the suspect spit onto the ground, they were able to scoop the saliva off the highest of a rain puddle to gather his DNA.[16]

Currently, there are only a few Forensic Meteorologists within the world, but the word is spreading. In Fall of 2018, The Weather Channel debuted a replacement show entitled “Storm of Suspicion”, which highlights ways in which weather and crime are intertwined. Will this show span a new 'CSI Effect'? They have to watch and see if lightening really can strike twice. Are there tons of forensic meteorologists across the world? No there aren't. They all know each other since it's such a small group. There are all different sorts of forensic meteorologists though. For example, some people just specialise in hurricanes and tropical weather. Some focus on air pollution meteorology. In addition to there not being that a lot of, they have their niche areas, making even smaller groups. Here at Weather Extreme, they have six forensic meteorologists, three of which are hurricane experts. Which weather elements are typically the foremost helpful when solving a crime?

Temperature, humidity, winds, precipitation, and sun. It's really a case by case basis, sometimes it's something small or all the above. For timing a murder, temperature and humidity and conditions around where the body was found are mostvital.[17,18]

Forensic meteorology has been utilized in all kinds of circumstances. While writing for Physics Today, Austin and Hildebrand tracked down a slew of lawsuits where a meteorologist was employed as an witness , including: murders, suicides, bombings, vehicle accidents, traffic accidents, skiing accidents, bad aircraft landings, kitesurfing accidents, agricultural disputes, property insurance disputes, building collapses, people slipping and falling, fires, and as a defence for stealing, looting, or trespassing. The range of weather involved in these cases can be equally as diverse-rain, snow, ice, tornadoes, hurricanes, air pollution, drought, floods, microbursts and epic storms can all lead to situations where a meteorologist takes the stand to carefully explain what the weather conditions were and how it impacted the environment.[19,20]

The frequency of particular weather events may be a common theme in civil cases. Did a city adequately anticipate normal severe rainfall when designing their sewage system and were overwhelmed by hit or miss freak event, or did they underestimate the predictable pattern of storms and fail to build an adequate system? When a roof collapses under the load of piled snow, was it a failure of engineering to create for the expected environment, or was the roof adequate and therefore the snowfall far above any reasonable expectation? A forensic meteorologist's analysis of the relative rarity of specific high-impact events are often pivotal testimony in determining fault during the next insurance and building disputes.[21-23]

Not every expert's testimony influences the case's outcome. A driver was hit by a bit of falling ice while crossing a bridge, with the fragment breaking his windshield and hitting him within the eye. He claimed the ice was a part of an icicle breaking freed from the bridge, while the local transportation authority claimed the ice must are flung off a passing truck. The forensic meteorologist testified that ice from a truck while be opaque, while an icicle growing on the bridge would be clear. An eyewitness said the ice was clear, leading the meteorologist to support the driver's accusation. Despite this, the jury found in favour of the bridge,

concluding that a truck was responsible for flinging ice.

Grundstein et al. did the study to quantify the influence of different ambient air temperatures and radiation values on vehicle cabin temperatures. It uses a singular maximum cabin temperature dataset that's linked with meteorological data on ambient air temperatures, solar radiation, and cloudiness. The study period included a spread of ambient air temperatures alongside a variety of cloudiness and radiation conditions. The first portion of this study investigates maximum cabin temperatures. These temperatures ranged from 41°C to 76°C. The magnitude of maximum cabin temperatures varied by both season and cloud coverage, which influenced the amount of solar radiation. Clear days in the spring average 61°C versus 68°C in the summer. The higher values are related to the higher ambient air temperatures in the summer. McLaren also found that the maximum cabin temperature was dependent on the initial ambient air temperature. Maximum cabin temperatures on cloudy days averaged approximately 10°C cooler than clear days with temperatures of 50°C in the spring and 58°C in the summer. The purpose of this research is to demonstrate that cabin temperatures can reach hazardous levels even under relatively mild conditions (i.e., cloudy with mild ambient air temperatures).

Using the cabin temperature and meteorological datasets, two models of maximum car temperatures were developed in this study. The models were designed to maximise the potential temperature and thus assume no ventilation and maximum sun exposure. They were also designed to use average daily meteorological values which will be more commonly available. When solar radiation data are available, the solar-based model is recommended because of its superior performance. These models could also be of use in forecasting hazardous conditions and helping to tell the general public of the risks of leaving children and infants unattended in vehicles. They can also be utilized in conjunction with the utmost vehicle cabin temperature indices that assign danger levels- “vehicle interior heat advisory” and “excessive vehicle interior heat warning”- that are consistent with official NWS terminology. In addition, the models could also be utilized in forensic analysis to reconstruct cabin temperatures. Guard and Gallagher found that over 25% of vehicle-related hyperthermia deaths occurred when parents or other caregivers intentionally left a child unattended in a vehicle, indicating a clear lack of knowledge about the heat-related hazard. Public advisories are documented to boost awareness. Sheridan noted that 90% of survey respondents from several urban areas were aware of heat warnings. However, many of the respondents did not actually modify their behaviour because they did not perceive a threat to their health. A warning of the danger of high cabin temperatures may be successful at both raising awareness and modifying behaviour if it clearly communicates the vulnerability of children and the distinct health outcomes, including serious heat-related illnesses or death.[24-26]

While for now it is somewhat obscure, forensic meteorology is slowly gaining credibility so far differently of bringing science and fact-based testimony into the courtroom. Even better, the quantity of knowledge available to tug into these cases is extensive, with detailed radar archives, rainfall gauges, volunteer observer reports, wind maps, and more to assist meteorologists with their analysis. But the important question is: how will forensic meteorology be glamorized when it makes its inevitable forced an entry the tv with its own crime-solvinghero?[27-30]

Conclusion:

The examples keep on coming. Every major natural catastrophe will bring out forensic meteorologists to work out what exactly happened. Inclement weather will elicit attempts responsible any accidents on the weather, leading meteorologists to make a decision where weather fits alongside human judgement, company policies, and equipment limitations. As we expect to stay getting more intense and more frequent extreme weather events as climate changes, forensic meteorology is simply getting to keep getting more important in sorting out what happened and how predictable it was.

Conflict of interest: The authors declares that there is no conflict of interest.

References:

1. Austin, Hildebrand, 2014. The Art and Science of Forensic Meteorology, Physics Today. [Accessed January 18, 2019]. Available from: https://physicstoday.scitation.org/doi/full/10.1063/PT. 3.2417#
2. John Eligon, 2011. Meteorologists Who Offer Not Forecasts but Testimony, The New York Times. [Accessed January 21, 2019] Available from: https://www.nytimes.com/2011/08/17/nyregion/forensic-meteorologists-provide-expert-testimony
3. Gregory N. Jones. Weather Modification: The Continuing Search for Rights and Liabilities, 1991 BYU L. Rev. 1163 (1991). Available at: https://digitalcommons.law.byu.edu/lawreview/vol1991/iss2/9.
4. Mika McKinnon, 2014. Forensic Meteorologists Solve Crimes You've Never Thought About, Gizmodo. [Accessed January 18, 201]. Available from: https://gizmodo.com/forensic-meteorologists-solve-crimes-youve-never-though-1586035339
5. The Weather Channel Staff, 2018. A Look into the Life of a Forensic Meteorologist, We Love Weather, accessed January 18, 2019, https://weloveweather.tv/life-forensic-meteorologist/
6. What is a Forensic Meteorologist? October 1, 2020 // Article by: Thomas M. Else
7. A look into the life of forensic meteorologist August 22, 2018 weloveweather.tv/life-forensic meteorologist.
8. https://gizmodo.com/forensic-meteorologists-solve-crimes-youve-never-though-1586035339
9. Goldstein M. Environmental forensics: the case for professional registration. Journal of environmental monitoring, 2007, 9: 396-399.
10. Potter S. Pieces of evidence. Weatherwise. 2004; 57 (3): 28-33.
11. Murphy L, Gauthier Thomas D. Determining air emission source contributions to soil concentrations. Environmental

claims journal. 1998; 11(2): 143-155.

12. Wilson WE, Suh HH. Fine particles and coarse particles: concentration relationships relevant to epidemiologic studies. J. Air & Waste Manage. Assoc. 1997; 47: 1238-1249.
13. Kimbrough DE, Suffet IH. Off site forensic determination of airborne elemental emissions by multi media analysis: A case study at two secondary lead smelters. Environ. Sci. & Technol. 1995; 29: 2217-2221.
14. Null J. Hypothermia deaths of children in vehicles. Golden gate weather services, 2008. Available from http://ggweather.com/heat.
15. Marty WT, Sigrist T, Wyler D. Temperature variations in automobiles in various weather conditions: an experimental contribution to the determination of time of death. Am J Forensic Med Pathol. 2001; 22(3): 215-219.
16. Bronstert A, Agarwal A, Boessenkool B, Crisologo I, Fischer M, Heistermann M, Kohn-Reich L, et al. Forensic hydro-meteorological analysis of an extreme flash flood: The 2016-05-29 event in Braunsbach, SW Germany. Science of the total environment. 2018; 630: 977-991.
17. Bisolli P, Dittmann E. The objective weather type classification of the German weather service and its possibilities of application to environmental and meteorological investigations. Meteorol. Z., 2001;10(4): 253-260.
18. Embar-Seddon A, Pass AD. Forensic science. 2nd edition. Calif: Salem Press, Pasadena; 2015.
19. Fuentes-Andino D, beven K, Halldin S, Xu C Y, Reynolds J E, Di Baldassarre G. Reproducing an extreme flood with uncertain post-event information. Hydrol. Earth Syst. Sci. 2017;21: 3597-3618.
20. Hurst R. An overview of forensic hydrology. Southwest Hydrology. 2007; 6(4): 16-17.
21. Keating A, Venkateswaran K, Szoenyi M, MacClune K, Mechler R. From event analysis to global lessons: disaster forensics for building resilience. Nat. Hazards Earth Syst. Sci. 2016; 16: 1603-1616.
22. Kunz M, Mühr B, Kunz T, Plapp LE, Daniell B, Khazai F et al 2013. Investigation of superstorm Sandy 2012 in a multi-disciplinary approach. Nat. Hazards Earth Syst. Sci. 13, 2579–2598.
23. Lischeid G, Balla D, Dannowski R, Dietrich O, Kalettka T, Merz C, et al, 2017. Forensic hydrology: what function tells about structure in complex settings. Environ. Earth Sci. 76, 40.
24. Grundstein A, Meentemeyer V, Dowd J. Maximum vehicle cabin temperatures under different meteorological conditions. Int J Biometeorol. 2009; 53: 255-261.
25. Guard A, Gallagher SS. Heat related deaths to young children in parked cars: an an analysis of 171 fatalities in the United States 1995-2002. Inj Prev. 2005; 11: 33-37.
26. McLaren C, Null J, Quinn J. Heat stress from enclosed vehicles: moderate ambient temperatures causes significant temperature rise in enclosed vehicles. Pediatrics. 2005; 116: e109-e112.
27. Sheridan. A survey of public perception and response to heat warnings across four North American cities: An evaluation of municipal effectiveness. Int. J. Biometeorol. 2007; 52(1): 3-15.
28. Mayerhofer C, Meissl G, Klebinder K, Kohl B, Markart G, 2017. Comparison of the results of a small-plot and a large-plot rainfall simulator – effects of land use and land cover on surface runoff in Alpine catchments. Catena. 156: 184–196.
29. Noon R. Forensic Engineering Investigation. CRC-Press, Boca Raton;2001: 445 pp.
30. Ziese M, Junghänel T, Becker A. Andauernde Großwetterlage Tief Mitteleuropa entfaltet ihr Unwetterpotential in Deutschland. [Accessed on June03, 2016].Available from: Online- Report of the German Weather Sevice (DWD). https://www.dwd.de/DE/leistungen/besonder reignisse/niederschlag/20160603_starkregen_mai-2016_meldung.pdf?__blob= publicationFile&v=3.