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Taking the Guesswork Out of Lightning-caused Wildfire

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Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Lightning and fire smoke.

Taking the Guesswork Out of Lightning-caused Wildfire

Summary

Lightning is a natural source of wildfire ignitions and causes a substantial portion of large wildfires across the globe. Simple predictions of lightning activity don't accurately determine fire ignition potential because fuel conditions must be considered in addition to the fact that most lightning is accompanied by significant rain. Fire operations managers need improved tools for prediction of widespread *dry thunderstorms*, which are those that occur without significant rainfall reaching the ground. It is these dry storms that generate lightning most likely to result in multiple fire ignitions, often in remote areas. In previous work the researchers developed a formula that estimates the potential for cloud-to-ground lightning when dry thunderstorms are expected. This new study demonstrated the value of the formula as a predictive tool for estimating the likelihood of dry thunderstorms across much of the western U.S. This expanded utility was accomplished by integrating the formula with the predictive capacities of the Pacific Northwest MM5 weather forecast model. In testing during the summers of 2004 and 2005 the majority of lightning-caused fires occurred where the predicted risk of dry thunderstorms was greater than 75%. These results indicate that this predictive tool can be very useful for identifying days when conditions are right for wildfire outbreaks due to lightning. This forecast tool is currently available 24 hours a day for the Pacific Northwest region at http://www.fs.fed.us/pnw/airfire. More work is already underway to expand coverage and improve usability, further supporting managers as they plan for the many potential fires that can be started by lightning from dry thunderstorms.

Key Findings

- New formula/model combination demonstrates value as a predictive tool for estimating the likelihood of dry thunderstorms across much of the western U.S.
- During testing, the majority of lightning-caused fires occurred where the predicted risk of dry thunderstorms was greater than 75%.
- Results indicate that the tool can be useful for identifying days when conditions are right for wildfire outbreaks due to lightning.

The lightning prediction game

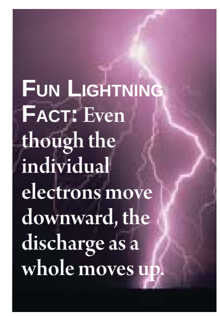
Lightning from dry thunderstorms causes most wildfires in the western United States. Predicting this phenomenon has been a long standing puzzle for scientists. Predicting when and where lightning may strike, and whether or not subsequent wildfires are likely, has been a game of chance for land managers. Where is it most likely to strike? Will there be a few strikes or hundreds? When will it begin, and when can we rest easy again? Step right up to the table and roll the dice.

Many things affect the likelihood that lightning will make a direct hit on any specific point within a given time span. The width of a cloud base, the height of the base above the ground, the conductivity of the soil and precipitation all affect the chances. Thunderstorms are always taking place on the planet. It has been estimated from satellite observations that lightning occurs approximately 50–100 times per second on a global basis. One of its many functions is to distribute and dissipate the 450 megawatt electrical charge that exists between the ground and the upper atmosphere. That's enough power to sustain a medium size city. At any given moment thousands of thunderstorms are in progress releasing this charge in small doses, sparing us from the electrifying experience of all that power zapping the planet in one shot. Lightning detection networks suggest that bolts blast the ground some 25 to 30 million times per year.

Thunderstorms are a double edged sword for land managers and firefighters in the western U.S. If a storm brings significant precipitation the moisture may help extinguish any existing blazes and hinder the ignition of new ones. But if the incoming weather is a "dry thunderstorm" where precipitation typically evaporates before reaching the ground, nature may be lighting some big matches—potentially hundreds of them. No one really knows exactly where, and there won't be much moisture to deter the flames. Dry thunderstorms crop up frequently during summer afternoons in the arid, mountainous West, where humidity is often so low that rain falling from thunderstorms evaporates shortly after being released from a cloud. This evaporating rain is called virga and can be seen from desert canyons to mountain tops. Curtains of rain billow down from the base of spectacular storm clouds then vanish into thin air. Towering tempests flicker with electrical charge, sending bolts of lightning racing toward the earth. This atmospheric theatre can be awe inspiring to watch, but it's a recipe for fires when lightning reaches the ground, rain doesn't, and fuels are ready to ignite.

Birth of a bolt

When George Carlin said, "Electricity is just organized lightning," he wasn't far off. It actually works both ways in that lightning is just electricity organizing itself. This organization occurs because typically the bottoms of storm clouds carry a negative charge which creates a localized positive charge on the ground. When the voltage builds to a level where the air can't insulate it anymore, a shot of electrons with a negative charge zigzags down from the cloud base seeking the path of least resistance in the same way water finds the easiest route downhill. As it approaches the area of positive charge at the earth's surface there is a "flashover' when the positive charge shoots up to meet the incoming electrons. The circuit is complete and a huge discharge follows instantly, starting at the ground and moving up to the cloud. This discharge, called the "return stroke," is responsible for the visible flash. It's only a few centimeters in diameter and as hot as the surface of the sun.



Fires start within the few milliseconds that this current is flowing. Once that first stroke establishes a route between a cloud and the ground the path is clear for more return strokes. The whole process can be repeated many times. If there is only one return stroke a lighting strike lasts about 20 milliseconds. It can last as long as 500 milliseconds if 10 or 15 return strokes occur. The more return strokes there are, the louder the thunder, the brighter the flash and the greater the risk of fire if conditions are right. The game is underway and the odds are anyone's guess.

Fire operations managers use a variety of fire potential assessments in their efforts to anticipate the likelihood of wildfire and to plan for resource allocation. Several planning tools exist to help narrow the guesswork when evaluating the potential effects of weather and fuel conditions on fire starts. These include daily weather forecasts and tools designed specifically for measuring fire risk such as the National Fire Danger Rating System (NFDRS) and the Haines Index, which indicates the potential for wildfire growth by measuring the stability and dryness of the air above a fire once it's underway.

But these tools aren't designed to address the specific question of whether or not a potential thunderstorm will be "wet" or "dry." Looking at previous lightning strike locations alone isn't useful for estimating risk of fire because of the complicated matrix of definitions and conditions surrounding the phenomenon. There is controversy about the definition of "dry lightning." Lightning can be said to be "dry"—or lacking significant concurrent rain—under several different storm conditions. "Dry" lightning occurs when thunderstorms form at relatively high altitudes with rainfall evaporating before it reaches the ground. Lightning is considered "dry" when it flashes outside the rain shaft of a "wet" thunderstorm; or is "dry" if it's spawned by a fast moving storm that, because of its speed, doesn't dump a lot of rain in one location.

Whether or not lightning will actually start a fire once it hits the ground depends on a lot of factors. Fuel conditions, humidity, concurrent rainfall amount and duration, and the success of fire suppression efforts all come into play. It's easy to imagine how a fire could start when a white hot bolt of lightning makes a direct hit on dry, flashy fuels, and there is little or no rain to thwart ignition. But it's also possible, in very dry areas or regions experiencing drought, for fuels to be so dry that fires can start despite significant rainfall. In Florida for example, studies of lightning strikes, fire starts and precipitation revealed that dry lightning is not an important mechanism for wildfires there. Most fires in the state start when lightning ignites dry fuels, even if it's raining heavily.

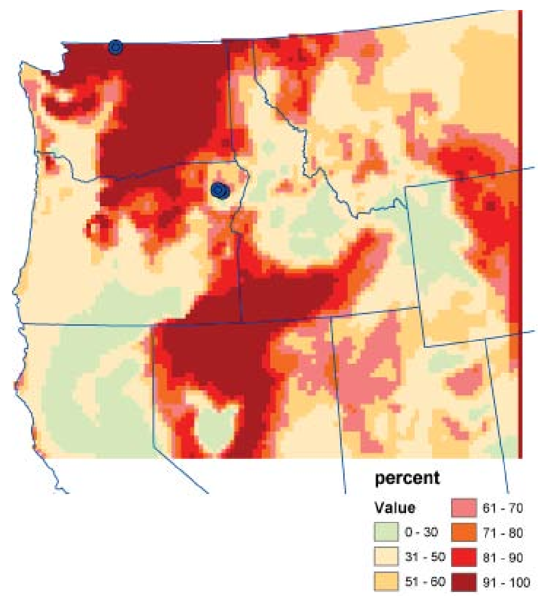
Regardless of the intricate variables and semantics, the importance of the relationship between wildfire and lightning that strikes without rain has been recognized by fire professionals for decades. But until this research project, predicting and planning for lightning caused fire starts was largely a crap shoot.

Evolution of the solution

Ten years ago Miriam Rorig and Sue Ferguson, research meteorologists with the Pacific Northwest Research Station (PNW), began addressing the increasingly pressing need for advanced prediction of dry thunderstorms and the lightning they generate. As members of the PNW AirFire Team, their research focus is to understand the role of weather and climate in ecological disturbance and develop decision tools for ecosystem management, fire operations, planning, and smoke management. With their most recent project, funded by the Joint Fire Science Program, Rorig and Ferguson created a lightning prediction tool that gives managers a peek at the cards before they're dealt: A web based model that predicts the regional likelihood of dry lightning strikes.

Rorig and Ferguson define dry thunderstorms as those with cloud to ground lightning that occur with less than a tenth of an inch of rainfall reaching the earth's surface. Their early studies showed that the ability to predict fire starts improved when they evaluated two separate indicators from upper air measurements: Atmospheric stability and moisture content. These two measurements allowed them to discriminate between dry and wet lightning days. In 1999, they used these indicators, derived from data around Spokane (WA), to develop a simple index from historical data. When they tested the index during the 2000 fire season they were able to effectively identify days with greater risk for dry convection and the resulting potential for lightning caused fires. This was the first formula that could actually discriminate between "wet" and "dry" lightning events, and the first step in giving managers the upper hand.

That study laid the foundation for this project that further improves prediction of dry thunderstorms by expanding the geographic area where the tool can be successfully applied and giving it 24 hour predictive capacity. They did this by integrating it with the regional meteorological model MM5, run by the Northwest Regional Modeling Consortium (NWRMC). By combining their original index with the predictive capacity and coverage of MM5 they demonstrated that the resulting model was useful beyond the original testing ground in Spokane. It's now available for use in the Pacific Northwest MM5 forecast region, and can be successfully applied to other regional forecast systems across the interior western U.S.



Example of 24 hour predicted probability of dry thunderstorm 5PM PDT August 2, 2004 and lightning-caused fires (Blue dots) on August 2, 2004. On this day, there was a high probability for dry thunderstorms over the central, northwest, and east central portions of the modeling domain. One fire ignited in north central Washington where the probability of dry thunderstorms was over 90%. Three fires ignited in northeastern Oregon, where the probability range was 60–70%.

Key players: Instability and water vapor

A thunderstorm can't form without the two critical ingredients that Rorig and Ferguson have targeted in their work: Instability and moisture. How much there is of both shapes everything about a storm and how elemental interactions will play out. It all boils down to differences in temperature. Without the temperature differentials required to drive convection and coax water to form a cloud, there will be no thunderstorm—be it "wet" or "dry."

Convection is the action of a parcel of warm air rising, which is caused by the unstable atmosphere where thunderstorms are born. The rise of warm air can be accelerated by the arrival of cool, heavy air that slides below it. Cool fronts lift warmer, lighter air like a spatula under a pancake.

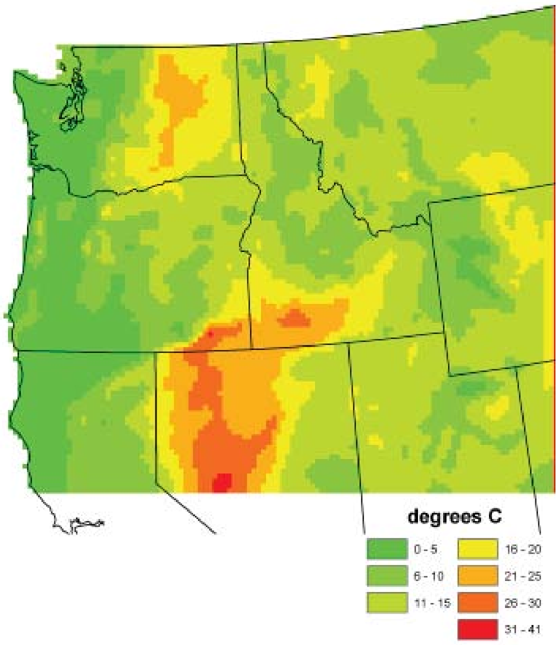
The amount of instability or convection that results from this action is determined by the degree of temperature difference between a rising air parcel and the air that surrounds it. A small difference doesn't generate much action. Rising air won't get very far if all it encounters is more relatively warm air (little temperature difference). The air is stable because the rising air parcel is the same temperature or cooler than the surrounding air mass, and therefore it tends to stay where it is, or sink back down to its starting point. It takes a larger temperature difference to start the convection engine. When warm, buoyant air rises and encounters surrounding air that's cooler (greater temperature difference), the warmer air parcel will continue rising because it's less dense than its surroundings. This is convection at work. It's the force behind the formation of those towering icons of atmospheric instability—cumulonimbus storm clouds.

The greater the temperature difference the farther the warm air can rise and the more unstable the air becomes. To get the numbers needed to calculate the likelihood of convection, Rorig and Ferguson measure the temperature difference between the lower and mid levels of the atmosphere. This determines whether or not the instability is sufficient to cook up lightning.

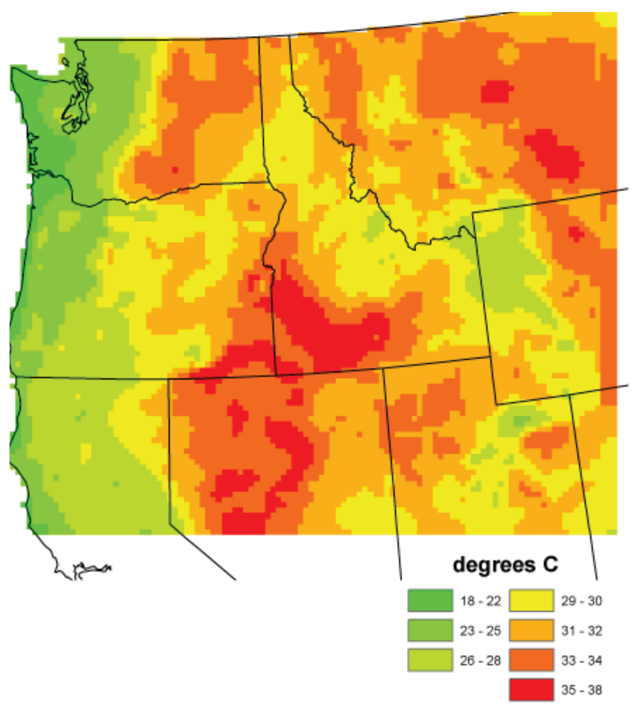
If there's enough convection, it's time to ask the million-dollar question: Will the lightning be "wet" or "dry?" How much moisture is (or isn't) in the system?

Even dry storms need some moisture to sustain their clouds. Another temperature difference tells the tale. Rorig and Ferguson looked to a measurement known as *dew point depression*, which is nothing more than the difference between the ambient air temperature and the dew point. This difference reveals how moist or dry the air is. When the ambient air temperature is closer to the dew point temperature (smaller temperature difference) it means more moisture. The air is nearing the limit of how much water vapor it can hold before it has to release it as precipitation, so the temperature doesn't have to drop much more for this to happen. Conversely, when the ambient air temperature is *farther* from the dew point temperature (greater temperature difference), it means the air is farther from the saturation point and will be proportionally drier.

The combination of measurements gave Rorig and Ferguson what they were looking for: "When we put these two parameters together—how dry it is and how unstable the air is—it gives us an indication of whether we are even going to have any convection and whether or not rain will hit the surface," explains Rorig.



a) 24 hour prediction of dewpoint depression (°C) at approximately 3,000' above ground level.



b) 24 hour prediction of temperature difference between approximately 15,000' and 3,000' above ground level.

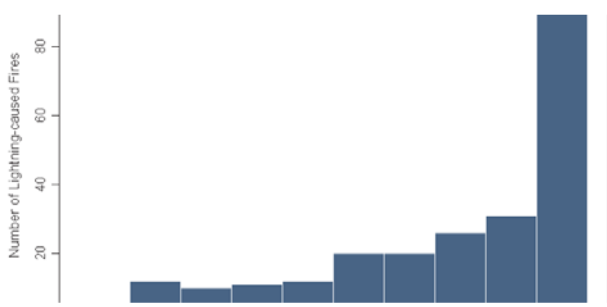
Testing ground: High and dry

Rorig and Ferguson tested their new model during the summers of 2004 and 2005 in the Pacific Northwest forecast region of MM5. This location gave them a chunk of the northern Rockies to work with, where the main contributors to dry thunderstorms are the high altitude of cloud bases and the typically dry air below them. Cloud bases and thunderstorms in the region tend to form around 12,000 feet above sea level. This qualifies them as "high-base" storms, meaning that they form in air that is higher, cooler, and dryer than the rest of the country. By comparison, Midwest thunderstorm bases are generally around 1600 to 3200 feet.

The researchers developed a formula using upper-air temperature and moisture data. These data are obtained from weather balloons launched twice daily from ground stations approximately 250 miles apart. Instrument packages are attached that measure temperature, dew point, wind speed and direction, altitude, and pressure. The data are then sent back to monitoring stations on the ground. Stations within the PNW MM5 region were used, as well as stations as far flung as Amarillo (TX) and San Diego (CA).

A complete set of statistics for both wet and dry days was compiled for most upper air monitoring stations in the western U.S., both inside and out of the PNW MM5 region. A day was classified as sufficiently convective for thunderstorm formation if there was at least one lightning strike within 6 miles of a monitoring station. Convective days were further categorized as wet (>1/10" of rain) or dry (<1/10" of rain) using measurements of actual precipitation on the ground at the stations. Once the statistics were computed, the researchers used the upper air temperature and moisture data predicted every day by MM5, and plugged it into the formula to estimate the probability of a thunderstorm being dry, should one occur.

240 large fires were started by lightning in the study during the test seasons. 97 fires (40% of the total) ignited in locations where the probability of dry lightning was predicted to be 90% or greater. 140 fires (58%) occurred with a predicted probability of 75% or greater.



Quantity of large lightning-caused fires vs. the predicted probability of dry thunderstorms for the summers of 2004 and 2005.

Management Implications

- Improved prediction of the risk of lightning-caused fire ignitions in the MM5 Pacific Northwest forecast area.
- Useful in and available to all regional weather forecast centers through the Fire Consortia for Advanced Modeling of Meteorology and Smoke.
- Can be applied to historical data to assess dry lightning activity for a given location over time.
- Allows improved preparedness and resource allocation for lightning-caused wildfires.

The game's not over

The results were enough to put the model into operational service via the Pacific Northwest Research Station website at http://www.fs.fed.us/pnw/AirFire. It's also available nationally to all regional modeling centers through the Fire Consortia for Advanced Modeling of Meteorology and Smoke. The researchers are also working closely with the California and Nevada Smoke and Air Committee and the Rocky Mountain Center to implement predictions of dry lightning risk in those regions.

The project completed yet another step in the ongoing work with dry thunderstorm prediction, but Rorig emphasizes that more work needs to be done to ensure reliability. Over-prediction can be a problem with the current model because the tool generates a probability of dry thunderstorms whether or not sufficient convection is expected. This makes the false-alarm rate high. An additional convective index is needed to complement the moisture index developed a decade ago. This would allow a single map indicating where the risk of dry thunderstorms is high *only in areas where convection is predicted*. With regard to precipitation, some days can be incorrectly classified as dry even though there may be significant precipitation falling close to—but not *exactly* on—the monitoring station. In addition, the sample size of their study was limited by two factors: only two fire seasons were surveyed, and only "large" lightning-caused fires (>100 acres) were used as valid indicators of lightning starts. There may have been plenty of other ignitions that either resulted in smaller fires that were suppressed, or for which fuels were too wet to allow fire growth.

Future work will involve collaboration with researchers at NASA's Storm Prediction Center to expand on their progress with predicting location and intensity of lightning outbreaks. They'll continue to expand prediction coverage throughout western North America to include both Alaska's interior and a portion of southern Canada that lies within the PNW MM5 forecast region. They'll apply data by sampling moisture and temperature variables in deeper atmospheric layers. Because the model has been in use for 3 years, they'll be able to use the results to verify prediction accuracy, including ignitions of smaller fires. This, along with the addition of a new convection index, should reduce over-prediction. They'll work to generate targeted predictions of large outbreaks of numerous thunderstorms that generate thousands of highly concentrated lightning strikes with the potential to ignite multiple fires and overwhelm suppression resources.

With continued research, it should eventually be possible to integrate the predicted risk of dry thunderstorms with fuel models and fire danger ratings to give managers a truly comprehensive tool for forecasting risk of lightning-caused wildfire. So although managers can't throw the dice away quite yet, this study improves their chances of winning the game.

Further Information: Publications and Web Resources

Lightning Probability Maps / Pacific Northwest Research Station: http://www.fs.fed.us/pnw/airfire/sf/

Final Report to Joint Fire Science Project: http://www.firescience.gov/projects/01-1-6-08/01-1-6-08_final_report.pdf

Rorig, et al., 2007. Model-generated prediction of dry lightning risk. Journal of Applied Meterology and Climatology, 46:605-614.

Rorig and Ferguson, 2002, The 2000 Fire Season: Lightning-caused fires. Journal of Applied Meteorology 41:786-791.

M. L. Rorig and S. A. Ferguson. Characteristics of lightning and wildland fire ignition in the Pacific Northwest. Journal of Applied Meteorology 38:1565-1575, 1999.

Scientist Profiles

Miriam Rorig is a Research Meteorologist and AirFire Team member with the Pacific Northwest Research Station. She conducts research in mesoscale meteorology to better understand the conditions that give rise to the ignition and spread of wildfires, and dispersion and air quality modeling for managing smoke from fires.

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Sue Ferguson was a Research Atmospheric Scientist and the AirFire Team leader with the Pacific Northwest Research Station. In September 2006, she was honored posthumously with the Forest Service Chief's Honor Award for Superior Science for her outstanding contributions to our understanding of fire and smoke dynamics as a result of wildland fires. She is greatly missed by her colleagues in the fire science community.

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Joint Fire Science Program
Manager's Viewpoint
WRITTEN BY MANAGERS FOR MANAGERS
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Predicting Lightning Risk

Written By: Terry Marsha

Purpose of this opinion piece

Manager's Viewpoint is an opinion piece written by a fire or land manager based on information in a JFSP final report and other supporting documents. This is our way of helping managers interpret science findings. If readers have differing viewpoints, we encourage further dialogue through additional opinions. Please contact Tim Swedberg to submit input (timothy_swedberg@nifc.blm.gov). Our intent is to start conversations about what works and what doesn't.

Problem

Rorig and Ferguson's research is concerned with the forecasting of "Dry Lightning." As such, primary emphasis is given to the forecasting of concurrent rainfall amount and duration. While this approach fits into the conventional concept regarding "critical lightning," it also has pitfalls and shortcomings that make it difficult to use operationally.

As a Predictive Services meteorologist/fire potential analyst in the Northwest, one important aspect of my job is to forecast daily fire activity. By "fire activity," I specifically mean both the number of ignitions as well as the probability of a "large fire" on any given day. The goal is to help facilitate proactive and sound fire resource allocation decisions by fire and resource managers based on the forecasted threat—or lack of—elevated fire activity.

While discussing this study's findings, limitations of the current concept of "dry lightning" will be illuminated and an alternative conceptual approach to critical lightning will be suggested for consideration.

Application for Land Managers: We Need to Focus on Forecasting Lightning Amount—Not Rain

As noted in this study, lightning is a huge contributor to overall fire activity across the western states and also represents the single most significant cause of "large fires" in the Pacific Northwest. It is, therefore, extremely important that we be able to determine the type of lightning event most likely to result in heavy fire activity—and be able to forecast it.

Between 2000 and 2007, approximately 49 percent of all wildfires in Oregon and Washington were caused by lightning. More significantly, 64 percent of all "large wildfires" were either directly or indirectly the result of lightning. However, only 5 to 10 percent of all lightning events actually resulted in large fires.

The term “dry lightning” has been used for many years and implies lightning with only minimal rainfall reaching the ground, a rather subjective concept. Rorig and Ferguson define dry lightning as a thunderstorm with a reported rainfall amount of 0.1 inch or less at a representative site. A survey of different National Weather Service (NWS) fire weather units would find various rainfall criteria operationally in use, ranging from ≤0.10 inches to ≤0.25 inches. The emphasis implied by the term dry lightning is on “rainfall amount.” However, this is not the entire story.

Operationally, the NWS does, rather subjectively, consider “amount of lightning” when it issues Red Flag Warnings for dry lightning. In Rorig’s and Ferguson’s study, lightning amount is not emphasized. Though rainfall amount is obviously important, over emphasis on rainfall amount in defining a critical lightning event leads to some pitfalls.

Though rainfall amount is obviously important, over emphasis on rainfall amount in defining a critical lightning event leads to some pitfalls.

Limitations on the Current Concept of Dry Lightning

1. The first limitation brought about by the current concept of dry lightning—that emphasizes rainfall amount as the primary determiner of a critical lighting event—is that the rainfall amount criterion used in the definition is largely arbitrary. Who really knows whether 0.10 inch is relevant or 0.25 is relevant? The fact of the matter is that no one knows for sure what the exact rainfall criteria might be. I suspect that there is no single correct criterion that would fit every location or fuel type. Due to fuel moisture conditions, even the same location probably would experience a variable criterion from one day to another (0.10 inch of rain on a very dry fuel bed would likely have a much different effect on fire activity than 0.10 inch on a very damp fuel bed).

2. Secondly, even if magical rainfall criteria did exist, it is nearly impossible to forecast for an individual thunderstorm let alone an individual lightning strike. Having spent more than 20 years as a fire weather forecaster in the NWS, I can say that most forecasters find it extremely difficult—if not nearly impossible—to skillfully forecast dry lightning in terms of a specific rainfall amount. This dilemma represents one of the NWS forecasters’ biggest forecast headaches. To borrow a term from Rorig and Ferguson’s study, more often than not, it is indeed a “crap shoot.”

3. Finally, there is the problem of verification. With a lack of an adequate network of rainfall recording sites, how does one objectively verify whether a lightning storm was wet or dry? Without the ability to verify an event or decision, further analysis and meaningful improvement in the process cannot take place.

As long as the term dry lightning dictates the conceptual model, such is the plight surrounding the forecasting of these critical lightning events.

An Alternative Concept for Fire Critical Lightning

Applied research needs to develop tools that can be applied operationally—as objective as possible, forecastable, and verifiable. Most fire and resource managers are probably more interested in whether a particular lightning event is apt to result in one large fire or 20 large fires rather than whether or not it will result in 0.10 inch of rain. A useful tool needs to be able to answer this question. Because I find the existing definition and concept of dry lightning lacking somewhat in its ability to do this, I therefore favor another way of thinking about critical lightning events.

An approach that has been developed by Predictive Services in the Pacific Northwest is a subtly different way of looking at and forecasting “critical” lightning. Note that I do not call it dry lightning. That is intentional. For all of the aforementioned reasons, we want to get away from a focus on rainfall amount.

In the Pacific Northwest, fire activity correlates best with lightning amount. When lightning amount is combined with fuel dryness—as measured before and after a lightning event—the relationship to fire activity becomes even stronger.

Essentially, fuel dryness is being used as a surrogate for rainfall amount. After all, fuel dryness, more than discreet rainfall amount, is of primary concern. Fuel dryness, rather than rainfall, also tends to be a more continuous field across the landscape. Everyone agrees that rainfall is more site specific and harder to forecast.

In the Pacific Northwest, algorithms have been developed for forecasting fuel dryness and lightning amount out through seven days. Furthermore, combinations of lightning amount and fuel dryness have been calibrated to number of ignitions and probability of large fires. These forecasts are objective, easily verified, and more readily forecastable than are discrete rainfall amounts.

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For the most part, the NWS fire weather forecasters in the Pacific Northwest have started adopting this concept. They see this technique as being much easier to forecast and verify. In the Pacific Northwest today, you increasingly see NWS Red Flag Warnings with verbiage such as “Red Flag Warning being issued for abundant lightning and very dry fuels” rather than for “dry lightning” as in the past.

Conclusion

Despite offering an alternative concept and approach, I want to applaud the sound research conducted by Rorig and Ferguson into what is without a doubt the most critical event affecting fire activity in the Pacific Northwest. I believe that the forecasting of a critical lightning event is the most important aspect of a fire activity assessment. This alternative method of looking at the critical lightning event that I have described, I also believe, lends itself better to operational considerations—including forecasting, verification, and calibration to fire activity. I would like to see even more research conducted that concentrates on forecasting lightning amount.

Ultimately, for any tool to be of value, it must be relevant and reliable enough to gain the trust of fire and resource managers to use. Good sound proactive decision-making is necessary to try and mitigate, as much as possible, the consequences of a potentially critical fire activity event such as a lightning episode.

Manager Profile

Terry Marsha is a meteorologist and fire potential analyst for the Predictive Services Unit at the interagency Northwest Coordination Center in Portland, Ore. He is employed by the Bureau of Indian Affairs. Before joining Predictive Services in 2001, Terry spent 27 years with the National Weather Service as a fire weather forecaster and incident meteorologist (IMET). From 1982 to 1996, Terry was Meteorologist In Charge of the Salem/Portland Fire Weather Office. His primary career interests are in statistical modeling of weather and fire potential. He has developed numerous statistical algorithms for forecasting weather and fire potential currently in use in the Pacific Northwest.

The information for this Manager's Viewpoint is based on JFSP Project 01-1-6-08, Predicting Lightning Risk; Principal Investigators were Miriam Rorig and Sue Ferguson.