3B.1 ANALYZING THE SOCIETAL IMPACTS OF SENSIBLE WEATHER: A PRIVATE SECTOR VIEW

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1. INTRODUCTION

It is becoming increasingly important in today's world for commercial meteorology companies to have a thorough understanding of the societal impacts that everyday weather has on the various industries that comprise their client base. To best serve its clients, commercial companies need to understand the specific weather needs of each of their clients. This includes individual weather parameters and also the timeframe each client is concerned with. Doing so will allow a private weather company to know which weather parameters to focus their attention on. Also, understanding which timeframe clients are most concerned with will allow weather companies to effectively prepare for high-impact weather events. Telvent, a leading provider of business weather information, provides a software as a solution (SAAS) model for its client base of over 14,000 unique organizations. Within the web-based software, known as MxVision WeatherSentry Online, is a Consulting Forum for clients to make specific weather inquiries to Telvent's team of 50 degreed and experienced Meteorologists. Clients post their weather related questions about any time period or aspect of the forecast they choose, and receive detailed responses back from a Meteorologist within 15 minutes. This study is a statistical analysis utilizing a sample of two years (July 1, 2009 through June 30, 2011) of Telvent's Online Consulting forum questions (over 12,000 forum questions over the 2-year period). The questions have been divided by major client industries and sample various weather parameters and timeframes the clients are concerned with. The study will determine which industries are most sensitive to the weather in each season, the specific weather parameters they are concerned with, and the time periods of concern, in order to paint a comprehensive picture of the societal impacts of sensible weather.

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2. INDUSTRIES SAMPLED

The six industries sampled in this study were Pavement Transportation, Construction, Sports/Turf, Public Safety, Utility, and Airport Operations. Figure 1 shows the distribution of questions by industry over the 2-year study.

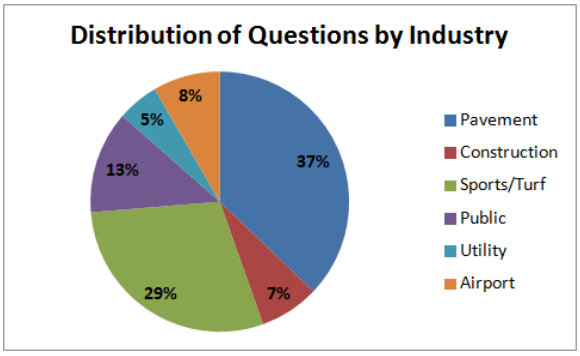


Figure 1: *Distribution of forum questions by industry over the 2-year study; sample size is approximately 12,000 forum questions.*

Telvent's Pavement Transportation clients consist of Municipalities, Counties, and State Level Departments of Transportation. The primary role of these organizations is to plow and treat roadway surfaces during the winter in addition to dealing with road construction. Their greatest weather impacts are snow and ice storms in the winter. Also, rain and thunderstorms impact road construction during the warmer months. Telvent's Construction client's weather related concerns include worker safety and maintaining the integrity of a jobsite. These clients are most active in the spring, summer, and fall months. Construction organizations are very sensitive to any type of precipitation. If an open, partially constructed roof or a fresh concrete pour is exposed to rainfall,

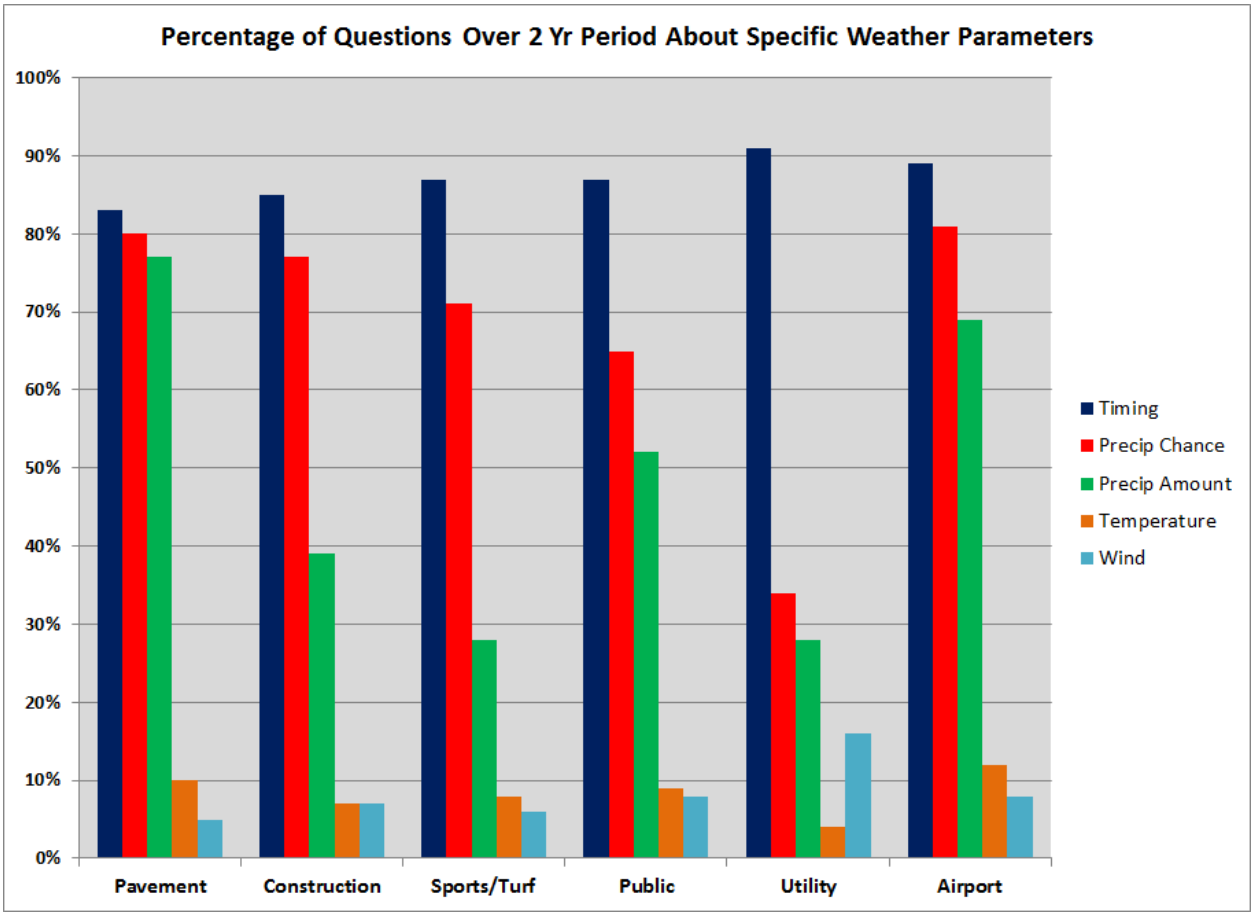
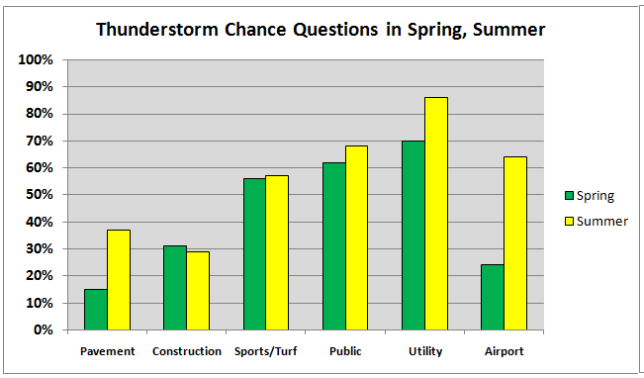


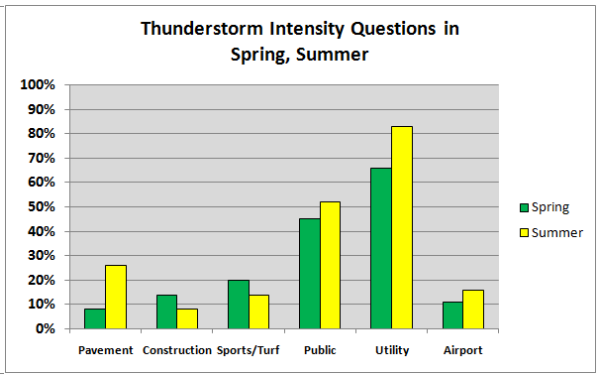
Figure 2: *This graph shows the percentage of questions from each of the six industries over the 2-year sampling period. Each colored bar refers to a different weather parameter: Dark blue is timing, red is precipitation chance, green is precipitation amount, orange is temperature, and light blue is synoptic wind. Note that for each parameter and industry, percentages will not necessarily total 100% because individual questions can, and usually do, address multiple weather parameters.*

these clients will suffer a financial loss. In addition, keeping construction workers safe from the dangerous impacts of lightning also plays a role. Telvent's Sports/Turf clients consist of high school, college, and professional outdoor sports teams, as well as resorts and golf courses. Similar to Construction clients, Sports/Turf clients are quite active in the spring, summer, and fall. Understanding the chances for rain and thunderstorms is vital for Sports/Turf clients to plan their events. Telvent's Public Safety client base encompasses city and county level police departments, fire departments, and emergency management agencies. Primary responsibilities include keeping patrons attending outdoor events safe from hazardous weather impacts. They are also responsible for dealing with injuries and providing shelter after a weather hazard has passed. Utility clients consist of electric, gas, water, and sewage companies. Weather hazards such as snow, ice, wind, and lightning can have a profound impact on their infrastructure. Finally, Telvent's Airport Operations customers include runway crews manning various airports across the United States. They are responsible for keeping runways clear of accumulating snow and ice. Airport Operations clients also include Ground Operations personnel who are sensitive to the impacts of heavy rain and lightning.

3. ANALYSIS OF WEATHER PARAMETERS

As shown in Figure 2, timing of weather events was the highest priority for all industries. Over 80% of all questions from every industry dealt with timing. Knowing when a weather event will occur is often more important than the predicted chance or amount of precipitation. Telvent's client base utilizes weather information to mitigate the risk of weather impacts on their operations, specifically, maximizing the efficiency of staffing resources and maintaining their safety. Thus, the client base desires as much information as



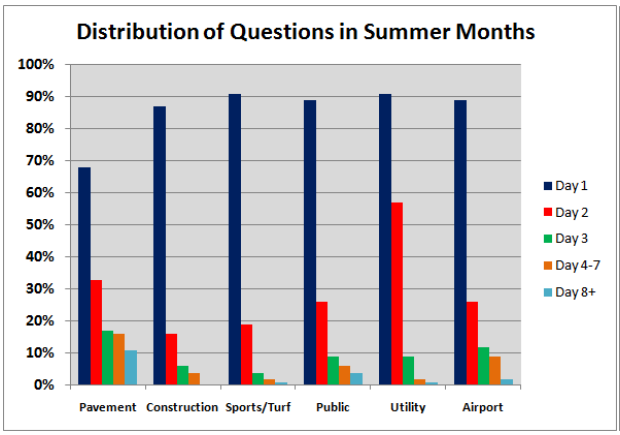


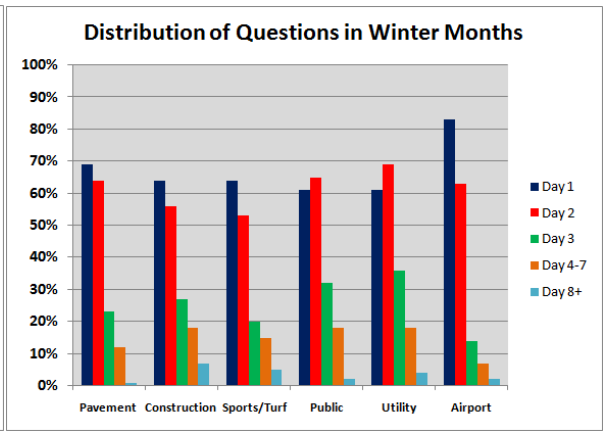
Figures 3 (left) and 4 (right): *Figure 3 depicts the percent of questions from each industry that dealt with thunderstorm chances in the spring months (Mar, Apr, May, shown by green bars) and summer months (Jun, Jul, Aug, shown by yellow bars). Figure 4 shows the percent of questions from each industry that dealt with thunderstorm intensity (or severity) during the spring and summer months.*

possible regarding *when* a weather impact will occur. For all six industries, there were higher percentages of questions dealing with precipitation chance than precipitation amount. This can be attributed to the fact that each industry has certain protocol that must be followed when there is any rain or snow, regardless of amount. For example, if there is any amount of accumulating snow on roadways or runways, departments of transportation and airport crews must perform snow removal operations. Because snow removal must be completed regardless of the amount of accumulating snow, the importance of understanding precipitation chance takes precedence over understanding the precipitation amount. However, with that being said, precipitation amount is still an important parameter for the Pavement and Airport Operations industries. The percent of questions dealing with precipitation amount was highest with the Pavement industry (77%). This is because the forecasted amount of snowfall is vital for these clients to plan their snow removal and chemical application operations (amount of chemical required, number of plowing crews required, etc.). Snow removal is also a major operation performed by the Airport Operations industry, and had the second highest percentage of precipitation amount questions (69%). Looking at the Construction and Sports/Turf industries, there were very large differences between the percent of precipitation chance questions and the percent of precipitation amount questions in both industries. For the Construction industry, precipitation chance questions outnumbered amount questions by 38%; for the Sports/Turf industry, that figure was 43%. This is because *any* amount of rain/snow/etc. will impact outdoor construction projects. Similarly, *any* amount of precipitation or the threat for lightning will impact sporting events, making their concern more “binary": Knowing whether it rains or not carries more relevance to these clients than how much rain will fall. The percent of questions dealing with synoptic wind speeds (16%) was higher with the Utility industry than any other industry, as their infrastructure (e.g., power lines) can be very susceptible to wind impacts. Compared to the Utility industry, wind speeds typically have less of an impact to the other industries and hence their percentages of questions dealing with wind were lower.

4. ANALYSIS OF THUNDERSTORM CHANCE AND INTENSITY PARAMETERS IN SPRING AND SUMMER MONTHS

As shown in Figure 3, during both spring and summer, the Sports/Turf, Public Safety, and Utility industries had higher percentages of questions dealing with thunderstorm chance than the other industries. The Sports/Turf and Public Safety industries are very concerned with lightning delaying outdoor activities. Utilities are concerned with lightning impacting their infrastructure, and must often hold crews on standby during thunderstorm events. So it is not surprising these three industries are the leaders in the thunderstorm chance questions. The Airport Operations industry had a much higher percentage of thunderstorm chance questions in the summer (64%) compared to spring (24%). Many of Telvent’s Airport Operations clients are located in areas that are prone to snow in the spring months. Thus, the airports in those areas are often more concerned with snow than thunderstorms in spring. But in the summer, airports have a high percentage of thunderstorm chance questions because runway crews obviously cannot work safely when lightning is nearby. The Pavement and Construction industries



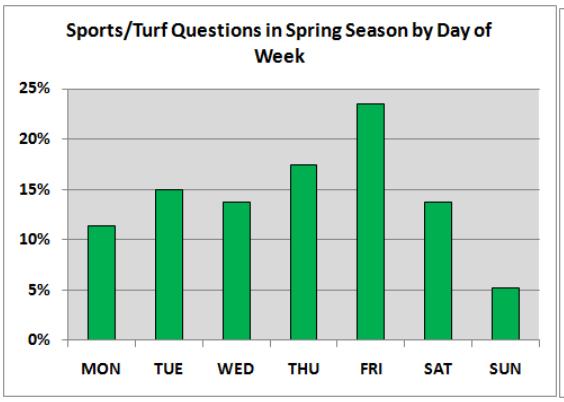


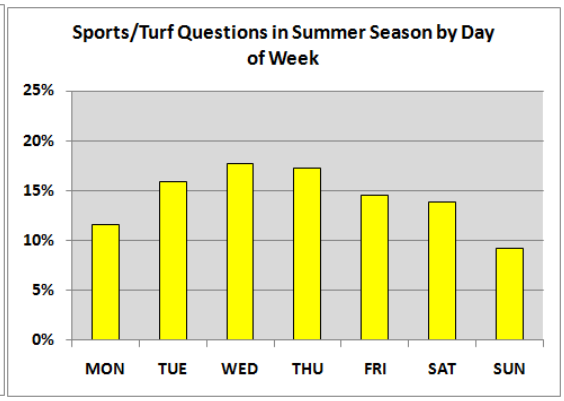
Figures 5 (left) and 6 (right): *Figure 5 shows the percent of questions from each industry during the summer months (Jun, Jul, Aug) dealing with specific timeframes (day 1, day 2, day 3, days 4-7, and days 8 and beyond). Figure 6 shows the percent of questions from each industry during the winter months (Dec, Jan, Feb) dealing with those same timeframes. Note that percentages for each industry and timeframe will not necessarily add up to 100%, because individual questions can, and often do, refer to more than one timeframe.*

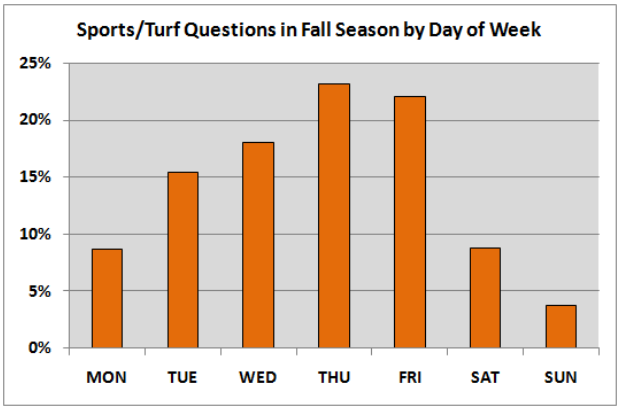
had the lowest percentages of thunderstorm chance questions. Typically their outdoor operations are sensitive to any type of rain, for example a concrete pouring job. Thus, often times it will not be as relevant to know whether or not the forecasted rain will contain lightning. If there is *any* chance of rain, outdoor operations are usually suspended regardless of whether or not there is a chance for lightning. There are, of course, exceptions to this (e.g., crane work), which the meteorologist must remain cognizant of. Figure 4 shows that the Utility industry had a much higher percentage of questions dealing with thunderstorm intensity than any other industry, both in the spring months (66%) and the summer months (83%). Intensity or severity of storms will affect how great the potential for power outages are (e.g., wind gust potential, tornado potential, lightning strike frequency). Utility crews will often have to hold crews on standby (and thus pay overtime wages) during severe thunderstorm events, hence their significant concern with storm intensity. The Public Safety industry was second highest, with 45% of its questions in spring dealing with thunderstorm intensity, and 52% in summer. Outdoor events with large tents for instance, will be susceptible to strong wind gusts in storms. Also, emergency managers will need to know thunderstorm severity to determine the risk for injuries to people. If a tornado outbreak is forecast they will need emergency personnel on stand-by. Therefore, it is no surprise that thunderstorm intensity is a very relevant concern for the Public Safety industry. Looking at Figures 3 and 4, one will note that despite being a leader in the thunderstorm chance questions, the Sports/Turf industry is not a leader in thunderstorm intensity questions. When it comes to thunderstorms, the turf industry's concern is often binary: If there is *any* chance of lightning, turf clients will be concerned. If there is no lightning, the level of concern drops. Whether a thunderstorm is "garden variety" or severe is not as relevant because a thunderstorm of any strength will impact and/or delay an outdoor sporting event.

5. ANALYZING TIMEFRAMES OF CONCERN

Each of the industries exhibited noticeable trends after analyzing statistics from the inquired timeframes (day 1, day 2, etc.) Figures 5 and 6 represent these trends during the summer and winter months, respectively. In these figures, day 1 refers to weather questions that will occur any time up through 11:59PM local time, day 2 refers to weather occurring from midnight to 11:59PM local time during the next day, and so on. Figure 5 shows that with each of the industries there is a very high percentage of questions dealing with day 1 in the summer months. Also with each industry, the percentages drop sharply on day 2. From day 4 onward, percentages in each industry are very low, 16% or less. Transitioning to Figure 6, there was clearly not a sharp drop-off from day 1 questions to day 2 questions; in fact, the percentages for day 2 were higher than for day 1 for the Public Safety and Utility industries. Also, in the winter months, the percentages of questions dealing with days 3 and beyond for each industry is higher compared to those same percentages during the summer. Looking at these two figures it is fairly clear that Telvent's clients'

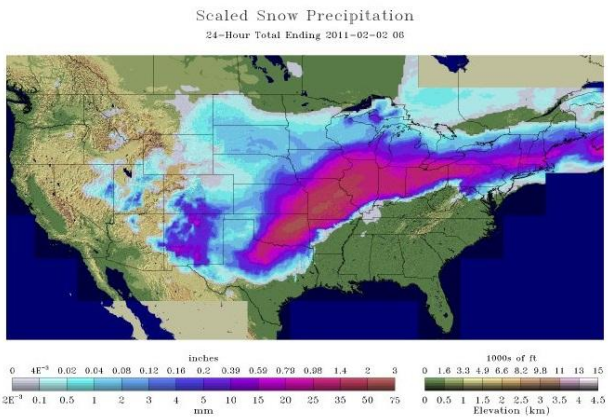


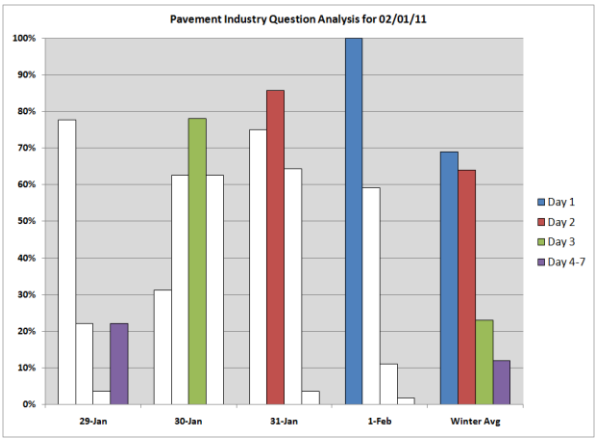




Figures 7 (top left), 8 (top right), and 9 (bottom): *Graphs showing percent of turf questions from each day of the week during the Spring months (Mar, Apr, May), Summer months (Jun, Jul, Aug), and Fall months (Sep, Oct, Nov), respectively.*

weather needs are much more short-term focused in summer than winter. For example, typical summer questions would deal with weather impacts for today's golf tournament or tonight's baseball game. When it comes to summertime activities, clients seem to only be concerned with the weather one day at a time; they typically wait until tomorrow before inquiring about tomorrow's weather. The exception is the Utility industry, which had the highest percentage of questions dealing with day 2 (57%). Utilities will often need to prepare for severe thunderstorm events the day before they occur, as their infrastructure can cover hundreds or even thousands of square miles. They will need to make decisions about how many crews to hold on standby, and which areas in their service territory will require standby crews. By comparison, the areal coverage of territory or infrastructure is typically considerably smaller for the other industries. Therefore, less preparation is required for weather events occurring in the summer (Recall that Pavement operations in the summer are usually smaller-scale road construction jobs compared to plowing multiple counties in the winter. So it is fairly safe to categorize the pavement industry's areal coverage as small in the Summer.). Summer impacts are typically mesoscale thunderstorm events. By contrast, in the winter months, the weather impacts are on a larger (synoptic) scale. Hence, they require much more preparation time to mitigate the overall risk on operations. Not only do snowstorms last longer than severe weather events, they cover larger areas and require extensive labor for removal of snow/ice after the storm has passed. Compare that to a severe





Figures 10 (left) and 11 (right): *Figure 10 is the 24-hour snow total for 02-01-11 (ending at 06UTC 02-02-11). Map shows the liquid equivalent of snowfall*. National Weather Service National Hydrologic Remote Sensing Center *(2011). Figure 11 shows the percent of questions from pavement industry dealing with specified timeframes (blue is day 1, red is day 2, green is day 3, purple is days 4-7) in the days leading up to the winter storms in the case study, as well as the day of the storm itself. On the far right side of the graph, winter average percentages for the timeframes specified are shown for comparison. For each day, the bar representing the most relevant timeframe is colored, with less relevant timeframes in white. For example, the bar for day 3 (green) is colored on Jan 30 because on Jan 30, the snow event for Feb 1 was the day 3 forecast.*

thunderstorm event where the total area impacted by severe thunderstorms is far smaller than a winter storm. There is often power restoration required after a severe thunderstorm event, but rarely is it on the areal scale as the amount of plowing that has to be done after a snowstorm. So, it comes as no surprise the percentages of questions for days 2 and beyond are usually much higher in winter than summer. Another factor to consider is the media often gives needed attention to an upcoming winter storm three, four, or even seven days in advance. It is no secret that industries utilize forecast information from the media in addition to commercial weather forecast products. If clients see the media advertising an impending winter storm, rest assured they will grow concerned several days in advance, and that in turn leads to more questions about the weather from days 2 onward. The decreased frequency of weather questions beyond day 1 in summer compared to winter could also be attributed to clients understanding that mesoscale rain and thunderstorm forecasting beyond day 2 can be quite erroneous. Therefore, one may conclude that clients ask fewer questions about rain and thunderstorms more than two days in advance because the understand the limitations of mesoscale forecasting that far out in time. Howe

ver, large-scale winter storms can be detected by numerical weather prediction models several days in advance. Hence, it would be more feasible for clients to ask questions about winter storms beyond day 2. One note of interest is that in the summer months, 11% of Pavement questions dealt with weather on day 8 or beyond. That figure is higher than the amount of questions from the Pavement industry in winter; it is also higher than any other industry's percentage for days 8+ in summer or winter. This is likely a reflection of the pavement industry's desire to obtain the outlook on the upcoming winter months. Once the winter season arrives, their focus shifts to days 1-7 rather than, say, asking about next winter. But in the summer, when there are obviously no labor costs with snow removal or chemical applications, these organizations can focus more of their attention on long-term weather. Other industries apparently do not need to make as many long-term preparations for anything beyond a week in advance, hence the very low percentages of questions dealing with day 8+ in both summer and winter.

6. ANALYZING TURF QUESTION FREQUENCY BY DAY OF THE WEEK

With the Sports/Turf industry being the most active in the spring, summer, and fall months, statistics were taken during those seasons to analyze client question frequency by day of the week. Figures 7-9 are bar graphs showing the distribution of turf questions during the spring, summer, and fall months respectively. Note that during the summer months (Figure 8), there is little variation in the day-to-day

percentages. This can be attributed to the fact that Telvent's Sports/Turf clients are more apt to conduct events on all days of the week during the summer. By contrast, during the spring months (Figure 7), there are noticeably more questions that came on Thursdays and Fridays (totaling 41% of all questions). Similarly, during the fall months (Figure 9), the days of the week with the most questions were Thursday and Friday (totaling 55%). A large portion of the Sports/Turf industry clients are high school sports teams, which conduct a majority of their sporting events on Thursday and Friday evenings during the Spring and Fall, which accounts for the trends shown.

7. PAVEMENT INDUSTRY WINTER CASE STUDY

During the winter months, an overwhelming majority of the forum questions come from the Pavement Transportation industry. In order to illustrate the pavement clients' tendency to latch onto a major winter storm several days in advance, a case study was performed analyzing statistics on the days leading up to, and on the day of, a major winter storm that occurred on February 1, 2011. Figure 10 shows the snowfall on February 1, 2011 (a major blizzard that struck the central United States, where many of Telvent's Pavement Transportation clients reside). Figure 11 is a bar graph depicting the percent of pavement industry questions dealing with specific timeframes from Jan 29-Feb 1. The graph also shows the winter average daily percent of pavement industry questions dealing with each timeframe. Note that on Jan 29 (4 days prior to the storm), the percent of questions dealing with days 4-7 was almost double the average daily percent of questions dealing with days 4-7 (seasonal average is 12%, but value on Jan 31 was 22%). On Jan 30 (Feb 1 would be considered the day 3 forecast on Jan 30), 78% of the questions dealt with day 3. This is more than triple the winter daily average of 23% dealing with day 3. On Jan 31, 86% of the questions dealt with day 2, compared to the seasonal daily average of 64% for day 2. Then on Feb 1, the day of the storm, 100% of pavement questions dealt with day 1 (compared to seasonal average of 69%). This trend clearly depicts how pavement clients hone in on major winter storms several days in advance, and that they will require continuous forecast updates in the days leading up to such a storm. From this case study, it is apparent that commercial weather companies with pavement clients must be prepared for increased customer correspondence at least four days in advance of a major winter storm. In some cases, frequency of questions can be several times higher than the seasonal averages.

8. CONCLUSIONS: APPLICATIONS FOR COMMERCIAL WEATHER COMPANIES

This study has several practical applications for commercial weather companies, some of which were mentioned above. Based on the client inquiries in the consulting forum, it is apparent that meteorologists should focus their attention on the timing of weather phenomena, as this is usually more relevant to clients than any other forecast parameter. Precipitation chance will often take precedence over precipitation amount, especially when dealing with Construction and Sports/Turf clients. However, for Pavement and Airport clients, precipitation amount is nearly as important as precipitation chance. If a commercial weather company has a large number of Sports/Turf clients, their meteorologists should focus more on thunderstorm chances rather than thunderstorm intensity during the spring and summer months. Also, increased meteorological staffing may be required around key days of clients' sporting events. If a weather company has a lot of Public Safety and Utility clients, both thunderstorm chance and intensity will be of significant relevance. Meteorologists can focus much more attention to the forecast for days 1-2 rather than days 3 and beyond during the summer months. But during the winter months, their attention should be focused through at least day 4 and perhaps as far as day 7. Also during the winter months, expect Pavement clients to latch onto major winter storms several days in advance, so weather companies should prepare accordingly. Finally, it may be prudent to monitor forecasts generated by the media in areas where clients are located during the winter months. Once the media starts to advertise a major storm, increased client interaction will surely follow. Understanding clients' specific weather needs is paramount for success in today's commercial weather industry. There are several key similarities and differences in client needs regarding weather parameters and timeframe of concern, and those client characteristics can change from season to season or even during different days of the week. With an increased understanding of client needs and behavior, commercial weather companies can be more prepared to meet the clients' needs and increase efficiency within the company.

9. REFERENCE

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