Done by Amanda Reynolds, Sean Romeo, Michael Priante, Max Gawryla and Marissa Lautenbacher

Thank you for considering our company for your weather forecasting needs. Here at

Weather Solutions Inc., we take pride in coming up with the best weather products for

commercial grocers across the country, and Weis is no exception. We have a team of skilled

meteorologists who are able to analyze all types of weather data and transform it into useful

information for our consumers to use.

Weather forecasting is an art. It takes skill to be able to interpret the various computer

models that exist today. However, we have come a long way since numerical weather prediction

models were first run in the 1950s. An example of how weather prediction models have
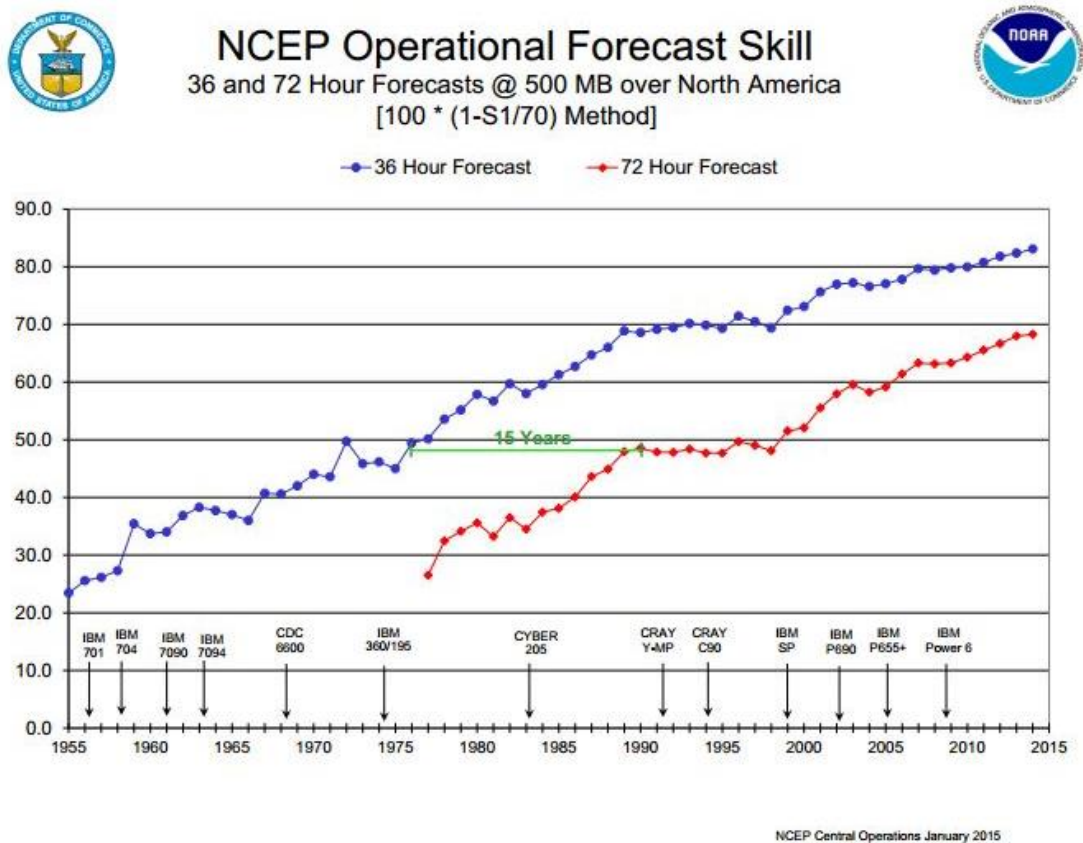
drastically improved can be seen by Figure 1.

Figure 1
Courtesy: Istvan Szunyogh: Texas A&M
http://atmo.tamu.edu/pdfs/szunyogh.pdf

Figure 1 above shows the improvement in forecasting accuracy over the years by models run by the National Centers for Environmental Prediction, or NCEP for short. The graph plots two types of weather forecasts. The first set of data points (which is marked in blue) shows the 36 hour forecast accuracy improvement over time. The second set of data points shows the forecasting accuracy of 72 hour forecasts. What is interesting to note here are the arrows pointing to key dates on the x-axis of this chart. These arrows indicate key dates where the computer mainframes, which run all of the numerical weather prediction models, received major improvements.

As technology improved, so too did the accuracy of the computer model forecasts. Even here in the present, we still have a lot of work to do in order to get accuracy to the 100 percentile. The next figure shows another accuracy plot from a well known model used by many forecasters.
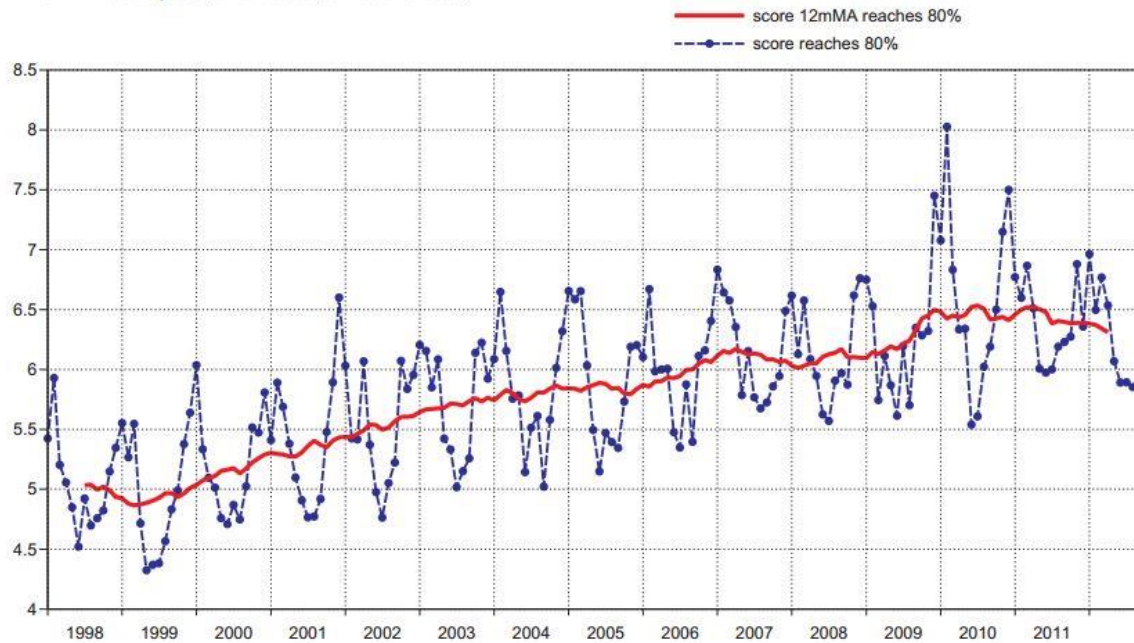

Figure 2
Courtesy: NCEP
http://www.nco.ncep.noaa.gov/sib/verification/s1_scores/s1_scores.pdf

Figure 2 shows the forecasting skill by one of global forecasting models we meteorologists use today. This model is called the ECMWF, which stands for the European Center for Medium Range Weather Forecasting or "Euro" for short. The Euro is and has been considered one of the best computer models that meteorologists can use to forecast the weather. This chart only goes out to 1998, but the trend shows that the forecasting accuracy of the European model is continuing to get better as time progresses. As the computer models start to increase in accuracy, so do the forecasts.

However, there are limitations to the existing computer models that we use on a day to day basis, and that would be computing power. These computer models run billions of calculations in their algorithms, which needs a lot of power to run. As the technology improves and gets smarter and faster, so do the weather forecasts. Luckily, we seem to be headed down the right path toward more accurate and longer range forecasts.

Other Products

Besides looking at computer models, we also like to look at some weather products produced by the National Weather Service. One product that we use in our weather forecasting is the Climate Prediction Center's US Drought Monitoring Index, as shown in Figure 3.
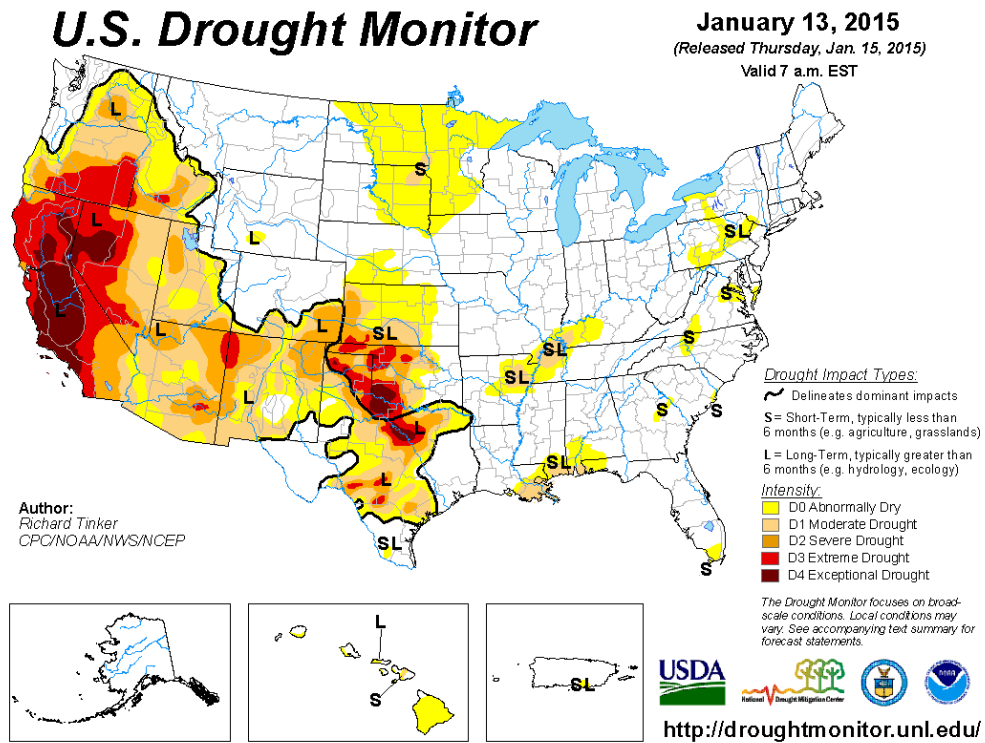
U.S. Drought Monitor

January 13, 2015
(Released Thursday, Jan. 15, 2015)
Valid 7 a.m. EST

Author:
Richard Tinker
CPC/NOAA/NWS/NCEP

Drought Impact Types:
~ Delineates dominant impacts
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/

Figure 3
Courtesy: USDA
http://droughtmonitor.unl.edu/

This map is not a forecast map, as it shows current conditions for many regions of the continental United States. The map shows the severity of drought for different areas of the country. The white color indicates little to no dry conditions, while the darker red and brown colors indicate much more severe dry spells. They also have more localized maps for different regions, as seen in figure 4 below.

U.S. Drought Monitor
West

January 20, 2015
(Released Thursday, Jan. 22, 2015)
Valid 7 a.m. EST
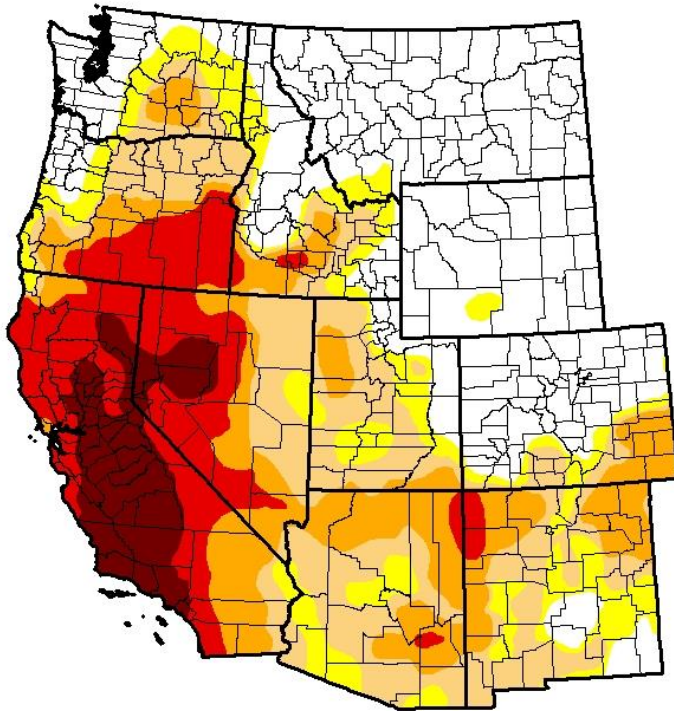
Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	35.52	64.48	53.09	33.62	18.52	6.35
Last Week 1/13/2015	34.29	65.71	53.21	33.18	18.52	6.35
3 Months Ago 10/21/2014	31.95	68.05	55.56	34.82	19.08	8.90
Start of Calendar Year 12/30/2014	34.76	65.24	54.48	33.50	18.68	5.40
Start of Water Year 9/30/2014	31.48	68.52	55.57	35.65	19.95	8.90
One Year Ago 1/21/2014	18.74	81.26	60.81	36.99	13.78	0.63

Intensity:

D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
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The Drought Monitor focuses on broad-scale conditions.
Local conditions may vary. See accompanying text summary
for forecast statements.

Author:
Richard Tinker
CPC/NOAA/NWS/NCEP

http://droughtmonitor.unl.edu/

Figure 4
Courtesy: USDA
http://droughtmonitor.unl.edu/

This is a closer view of the drought index, valid for January 20th at 7am EST. These close view maps help us get a sense of conditions in the more drought-prone regions of the country. It is crucial for us to figure out what areas have received the least amount of rainfall, as this could potentially hurt the crop growers in regions like California. Such droughts will eventually influence the market and thus raise prices. We will talk more about the grocery market in the next section.
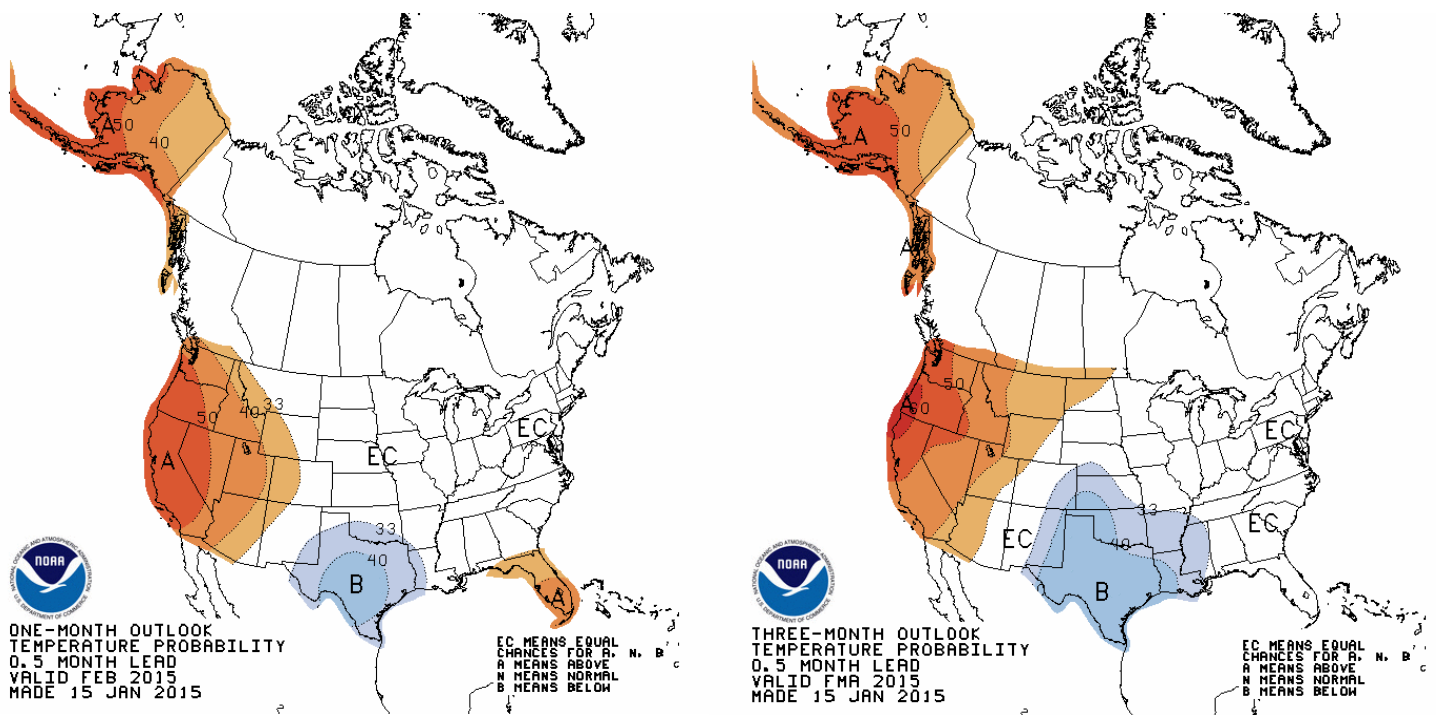
Figure 5 & 6
Courtesy: CPC
http://www.cpc.ncep.noaa.gov/

Besides looking at the drought indices, we also like to look at some of the other weather products from the Climate Prediction Center (CPC). Figures 5 and 6 are other weather products we use, which gives us the one-month and three-month outlooks of temperature anomalies for the entire country. What this essentially means is that these maps give us a better understanding of what areas are likely to receive below average temperatures or above average temperatures. The blue colors on the map indicate colder than average temperatures, while the red colors on the map indicate warmer than average temperatures. The "EC" notation represents the white colored index, which means average temperatures can be expected for the areas shaded in white. These temperature probability products are also available on a weekly and bi-weekly basis.
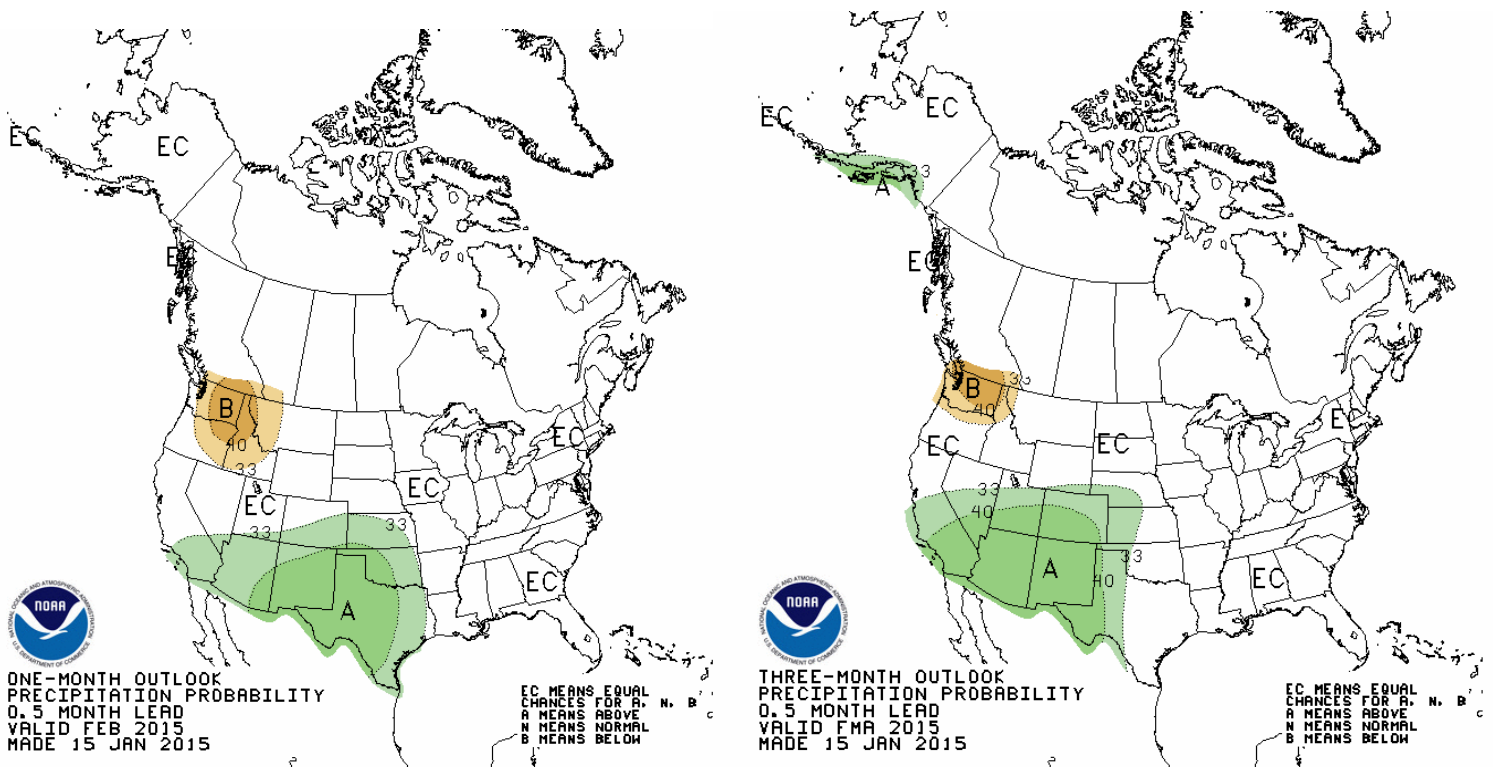
6

Figure 7 & 8
Courtesy: CPC
http://www.cpc.ncep.noaa.gov/

These next two figures also come from the Climate Prediction Center's website. They

show the overall precipitation probabilities for the entire month. What this means is that they

show the chances for areas to receive above average precipitation or below average precipitation

over a one and three month time span. The green colors on these maps indicate areas that are

forecasted to receive above average amounts of precipitation, while the brown colors indicate

areas that are forecasted to receive below average precipitation amounts. Likewise, the white

"EC" color on the map indicates areas that are expected to receive average amounts of

precipitation. These weather products, when compared with the temperature outlooks as seen in

figures 5 and 6, can help us determine "big impact" areas across the country. These big impacts could range from severe droughts to massive floods or massive cold snaps and winter storms.
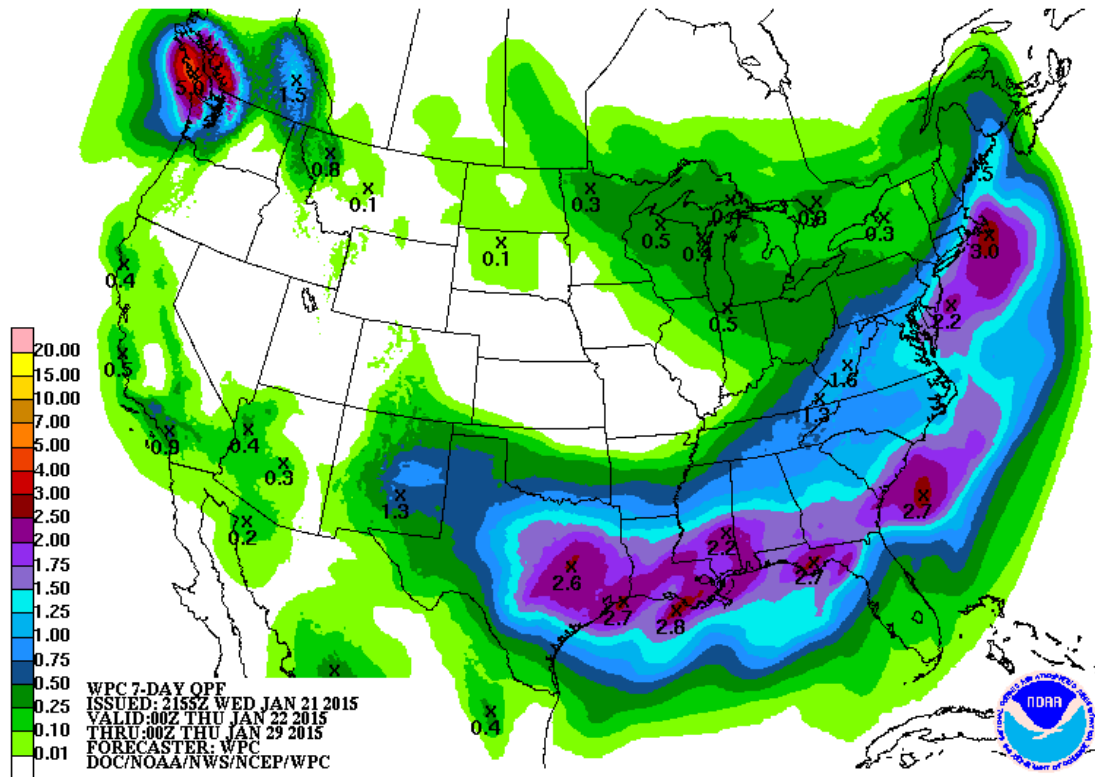

Figure 9
Courtesy: WPC
http://www.hpc.ncep.noaa.gov/

Figure 9 comes from the Weather Prediction Center's website. This plot is a forecast which displays the seven day QPF forecast for the Continental United States. QPF stands for Quantitative Precipitation Forecast and it is measured in inches. Areas on the map, indicated by lighter blues and purples, represent rainfall amounts between one and two inches of rain. Lighter green colors represent lighter accumulations of less than a half inch. The accumulated rain forecasted here is a running total that goes out seven days. This graphic gives us a better

understanding of storm systems and how they can affect certain regions of the country. Knowing where the heaviest amount of precipitation will fall (whether it be rain or snow) is crucial in pinpointing our forecasts.

The last Figure below is taken from the Storm Prediction Center's website and shows the Severe Thunderstorm Outlook. This outlook index is based on many categories ranging from marginal (listed as a light green color) to high (listed as a pink color). The categories help show the severity and persistency of severe storms, which range from extreme rain and hail events to dangerous tornados. We can use this product to figure out areas that are more likely to develop severe thunderstorms, which can do a lot of damage.
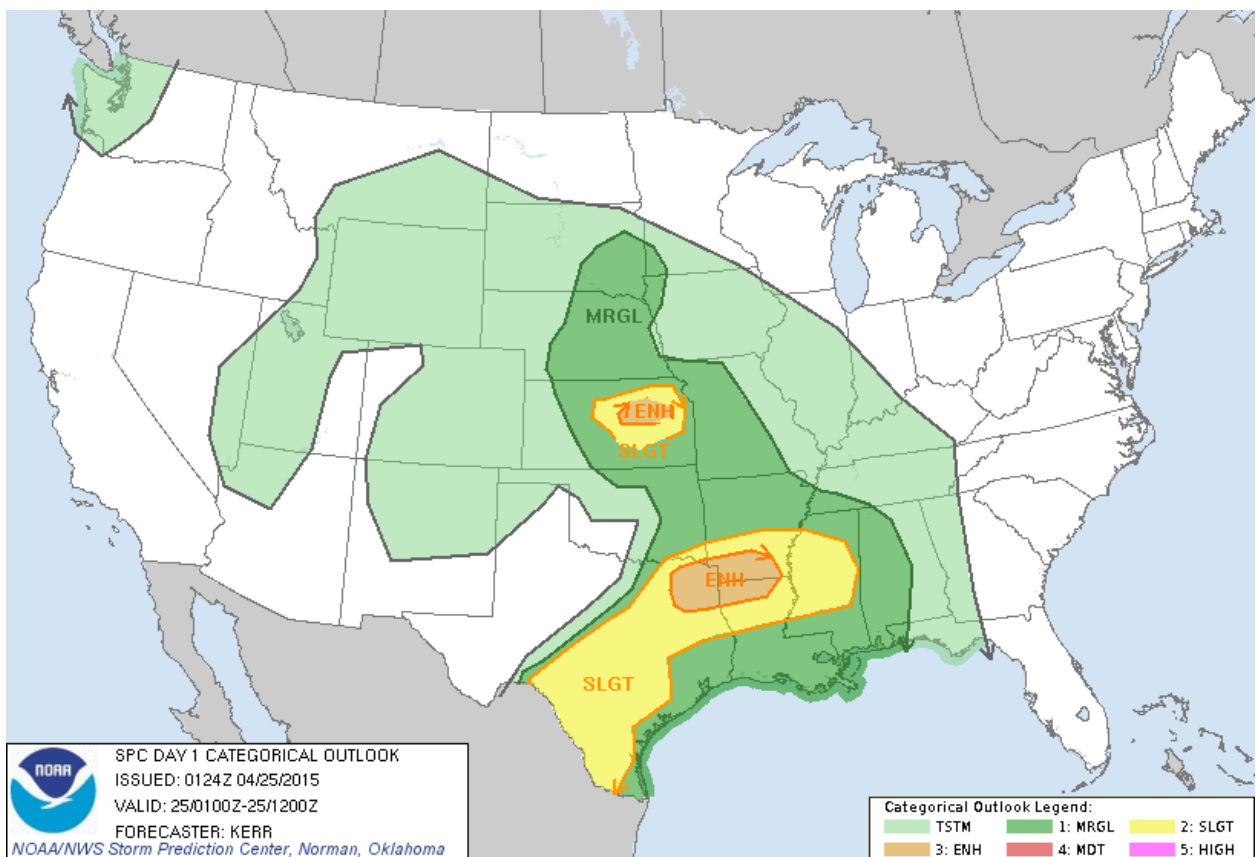

Figure 10
Courtesy: SPC
http://www.spc.noaa.gov/

What we have showed you here are just some of the products that we take from the National Weather Service. We take these weather maps and forecasts and implement them into our weather forecasting algorithms. What we have not listed in this section of our report are the countless computer model data that our team looks through, in order to help aid in the formation of forecasts. We have shown you how Numerical Weather Prediction models have improved since the 1960s, but we also stressed that the computer algorithms are not perfect. It is easy for someone to learn how to read a map, but it takes a heavy education in meteorology to learn how to decipher the maps and analyze them.

At Weather Solutions Inc., our team of expert meteorologists have years of experience, working with large sets of data and computer model maps. They have the capability to sort through countless model outputs and combine skills acquired over the years to come up with detailed and reliable forecasts. Although we have presented you with a detailed look at how we forecast, we haven't explained how this affects your company. In the next sections, we will go over how our forecasts affect your grocery expenses and profits, and present you with a complete weather index that we feel produces the best results for your company.

In the grocery industry perishable items make up a little over half of the profit margin for supermarkets, which is why our index is focused on these items and saving you money by letting you know how weather will affect the shipping and sales of these items. Perishables are especially vulnerable to quickly changing weather conditions throughout the year. In winter, heavy snow and ice storms can affect which items fly off the shelves, such as the staples; bread, milk, and eggs. Those are the main items that everyone wants to grab on their way home from work when a large storm is approaching, fearing they may be stuck in the house for a long period of time. Other items such as rock salt, ice scrapers, and shovels are in high demand when heavy

snow is forecasted because many people do not take inventory of winter supplies until a storm is approaching and are suddenly desperate for these items.

Advertising of items is done on a weekly basis, and these items are chosen months in advance, by the corporate headquarters with no knowledge of weather conditions. Advertising is not done specifically for weather events. However capitalizing on these weather events presents an opportunity for stores to increase profits if they also increased the frequency of their advertising, or related it toward current weather events. This could be done at a regional level or on a store by store basis. Managers of each individual store would decide what should be advertised dependent on the weather.

In the event of a winter storm, grocery stores should increase their orders of bread, milk, eggs, and other perishable items 3 to 4 days in advance. However, besides these essential items customers would also want to stock up on other items that an individual shopper would typically buy on a normal basis. In regards to advertising, the individual stores may want to place sale items next to these essentials or near registers so shoppers would be more enticed to buy them as an "impulse buy". This could increase the sales of individual stores, and cut back on spoilage as well as get customers to buy normally slow selling merchandise.

In the summer time, if a threat of a tropical system becomes apparent, many stores will ask for a larger stock of batteries. This is in case of power outages; customers want to feel more prepared. Heat waves can also impact sales in stores and managers will ask distributors to send items such as fans, ice, and small air conditioning units.

Shipping:

Shipment of merchandise is done on a regular weekly basis. However, instances of extreme weather or national holidays may cause some shipments to be delayed. Depending on where the merchandise is shipped in from, the store can order the merchandise and receive the shipment the following day if the distributor is close enough to the store. In cases such as getting perishables such as dairy items, it may take up to 3 to 4 days to receive an emergency shipment. Stores that are further away from the centralized Weis distributor and warehouse in Milton, PA will have a longer shipment time, and will have to put in the order much sooner than stores more central to Milton. In the case of a winter storm, certain items such as bread, need earlier notification for the shipment to come in on time. If a large enough storm is forecasted than the corporate headquarters will get involved and redistribute supplies. If there is already an upcoming shipment, then adjustments can be made before the regular weekly shipment goes out. This could be a huge money saver for Weis if the weather is predicted well in advance. Then stores could adjust their weekly shipments to compensate, instead of spending the money to send another truck a few days later. This would save Weis time, fuel, and shipping costs. Adjustments in shipping must be done 2 to 3 days in advance.

Shipments coming from areas that frequently are forecasted to get large winter storms such as Buffalo, NY can affect shipments coming from that area. If there is a major snowstorm that affects the distributor of a certain product, that could mean potential issues for stores that need the product from the affected warehouse. Increased warning time for these events could help Weis send out trucks from their distributors ahead of weather that could prevent travel. To help the distributor being impacted, a cross stock is put into play. A cross stock is when a certain product is sent to a warehouse in an area that would be less adversely affected by the storm. Then that product would be sent on another truck from the secondary warehouse to the stores in

need. Advanced weather forecasting could improve the frequency and mobility of certain products so that shipment delays would be less likely in the event of an impactful weather system. Sometimes trucks can be delayed by severe storms up to four days, meaning stores could miss up to two shipments. This could cause some minor impacts on some stores sales numbers. More frequently using cross stocks and getting trucks out of the way of impending weather events could help prevent stores from running low on essential items. Stores frequently request more perishable items than are needed, in order to prevent from running out. It is always better to have extra, and sell the surplus product at a discount and still have more income, than it is to run short. If a store would run short, it causes them to garner a bad reputation. When stores run out, it creates a lasting impression on people and customers will look elsewhere when the next storm approaches.

If a shipment is received that is broken, damaged, or spoiled the stores themselves do not take the loss. Stores will receive a credit from corporate for the items. Damaged or spoiled items include dented or broken packaging, an expiration date that has passed, as well as a short sell by date. A short sell by date for a product means that the store only has one to two days to sell it. If items were damaged in transit, then Weis's warehouses are responsible and will take the loss in revenue. Other perishable items that have expiration dates that have passed or have short sell by dates will go back to the vendor, and Weis as a whole will not be held responsible for that type of spoiled product. However, if the perishable items were not properly rotated in the warehouse stage, then corporate would be responsible for that loss. In order to prevent spoilage of perishable products, stores will rotate out their own products, which also known as culling. This a frequent practice among stores, and they will put items with the closest expiration date closest to the front of the shelves. Culling is done on a daily basis. Culling is done on a store by store

basis. Some items though, depending on the vendor are a guaranteed sale. A guaranteed sale is if the item does not sell, then the vendor will pay the store for the item. However, guaranteed sale vendors are often quite rare, especially in the perishable department. In the event that a vendor would force an item, meaning that a vendor intentionally put a spoiled or damaged item on a truck attempting to conceal the it; the store could send it back to the vendor upon noticing this item and receive a credit.

Email, social media, and mobile apps are all used in terms of digital advertising. However, advertising is done on the corporate level months in advance. This method makes sense in terms of more traditional media such as newspapers, but with the use of digital advertising, alerts can be sent out to customers regarding impending storms and sale items during the big rush before a storm hits. This type of advertising can be quickly changed and updated by the store or regionally by the company. This could be something for Weis to capitalize on and and sell other items, during the large rush to the stores.

Prices of items will only be effected during the longer term weather events. For example, if the area from which the distributor receives a product is experiencing a drought or a frost on orange crops in Florida then the price will, in the longer term, rise for those items. Price changes are done on a weekly basis, and are done throughout the store and not only on certain departments. The stores will be notified by corporate if they would be limited on certain items on a week to week basis. Stores will notify the customers if the limitation on the product is extreme. If they can't get their product from their normal vendors, then the company will have to import from further away leading to increased shipping prices. Wherever the distributor can get the best quality and price of a product is where the supermarkets will typically buy from. This is mainly done at the corporate level, stores will only get involved when trying to get local growers'

products into their stores. However, not all local farms can sell to grocery stores. The farmers themselves must have a certain level of insurance to both protect themselves and their customers. Local growers in the northeast regions are typically found to supply produce during the summer months.

Within our index we have created we decided on several weather variables that we believed to be most important in the success of a grocery company such as Weis. We took into account two major parts to the grocery industry, shipping and sales. They are set on two separate time scales as shipping is done on a weekly or bi-weekly scale as compared to the sales which is either weekly, daily, or multi-daily.

Within the shipping industry there are several weather variables that we believed were crucial to creating a successful weather index such as Wx Wise. These include Temperature, Probability and Type of Precipitation, Wind Speed, Cloud Cover, Visibility and amount of time that a driver would be on the road. The shipping index has a base value that starts from a point value of 10 which would represent a seasonal weather day. Based on various weather conditions, points can be added or subtracted from this number. The exact conditions and their impacts are shown below.

Temperature can be a major factor for the road conditions, especially in the winter. We tried to take into account how the roads react to different temperatures, especially during the winters. The first method we used was by adding points if forecasted temperatures were below 32 degrees Fahrenheit. This is because any moisture that would fall would likely freeze onto the roads making them slick and dangerous for truck drivers. Similarly, more points were added if the forecasted temperature was between 28 and 36 degrees Fahrenheit. This adds on to the idea

above, but roads can be even more hazardous because drivers may not realize how icy the roads could be. The last temperature range that we added points for was for temperatures below 15 degrees Fahrenheit. Below 15 degrees Fahrenheit, road salt does not work effectively. (http://www.dot.wisconsin.gov/travel/road/frequentlyaskedquestions.htm). This makes driving very difficult and dangerous because there is likely no way for the ice to melt, leaving a slippery, sliding mess.

The second variable we took into account was the probability and type of precipitation. One of hardest things for meteorologists to predict is the probability that a given weather event will happen. This is why we knew that we needed to take this number into account for our weather index. This was done by creating a scale to determine the likelihood that the precipitation would occur. These point values were then multiplied by a number that correlates to the expected precipitation type. The multiplication of these two numbers then provided a relatively accurate synopsis of what the most dangerous conditions would be. For more clarification of this please refer to the appendix pages.

Another variable we decided to use was wind speed. As trucks generally have a very large profile, they must endure the wind even though even small amounts of wind could significantly affect the truck. Wind speeds below the 25 mph mark will only have a minor effect on trucks. However, sustained wind speeds between 25 and 39 miles per hour or gusts of up to 57 miles per hour, the National Weather Service issues a "Wind Advisory" which indicates that there are likely gusty winds that could be harmful to trucks, their products and drivers. With sustained wind speeds greater than 40 miles per hour or gusts of over 58 miles per hours, the National Weather Service issues a "High Wind Warning" which means that it is very dangerous for trucks to be on the road for their own safety and the safety of others around them.

(http://www.weather.gov/ctp/wwaCriteria) For that reason, we made 3 grades of values that would be added to the original base value based on the wind conditions. We will use the NWS guidelines for the most part when calculating the wind effects.

The fourth variable that we deemed important to create our weather index was cloud cover. If there were snow or ice on the ground and there were no clouds in the sky, then the sun would be likely to help melt some of the precipitation off the road. On the other hand, if it were fully cloudy, then there would be no positive effect but there would be no negative effect either. For this reason, we decided that if there were sunny skies we would subtract values from the base which would result in an overall improvement in the shipping conditions. Conversely, if there were cloudy skies, there would be no positive effect so nothing would be subtracted. This results in an accurate representation about how the sun might play a role in road conditions. However, this variable is only usable in the event of ice or snow being on the roads.

The final weather based variable that we used for the shipping index was forecasted visibility. Typically fog and other weather phenomena can significantly reduce the distance that a driver can see. This lack of visibility means that drivers need more distance to stop, and it means that accidents are more likely to happen because they cannot see the roads or other vehicles as clearly.

In addition to the weather variables, we also included amount of time that the truck drivers drive per day. This is because even though a driver would hypothetically drive further given more time, there is more of a risk because they would likely be more tired which would be more of a liability. Taking this into account means that there is more accountability in the amount of time that a driver would be on the road.

By utilizing all of these variables in a particular fashion, we are able to minimize your shipping costs both in finding the safest and fastest route while also minimizing the amount of spoilage. This can save you the most money, therefore keeping your profit margins high.

For the sales index, we focused on fewer variables that we believe best represented the sales industry. These conditions are primarily experienced in the winter, but we are working on a summer index as well. The variables that we felt were most important to sales were the departure from normal temperature, the forecasted precipitation amount and type and the amount of time until the event is expected to begin. The combination of these three variables, we felt, best represented the complex nature of the sales industry.

Similarly to the shipping index, in the sales index temperature plays a major role. However, due to the changing nature of the temperature due to seasons, we decided that a better representation of temperature for sales would be departure from normal rather than the actual temperature value.

Think about it this way. If it is the middle of January and temperatures were to soar into the mid 50's, people would be excited and would immediately go out to the stores and purchase various items such as outdoor equipment and food items. On the other hand, if it's in July and temperatures drop into the mid 50's then people will think that it is cold and will stay inside, the same could be said for 100 degrees in July as well as people will stay inside and avoid the heat. Point being that even if the temperature is the same or the departure from the average is the same, the impacts on sales are very different. Using departure from normal temperatures helps narrow down what those impacts may be. With a base similar to the shipping index, points can

be added if temperatures are above normal in winter, and subtracted if temperatures ae below normal.

In addition, we tried to take into account the "hype" that consumers may encounter from their local meteorologist or national media outlets. When a storm is approaching an area, consumers tend to fear the worst and will stock up on everything, particularly what the grocery industry considers staples. This means an increase in sales. However there is an ideal window when most people gear up to brave the winter and go to the stores. There is also likely a downturn of sales right before the storm begins because consumers don't want to be stuck out in the storm when it begins. We factored both the timing of the storm and the amount of expected precipitation together by multiplying them to create a new weather variable that takes both variables into account equally. This is then added to the score from the departure from normal temperature value to create a score out of 100.

For the executives to fully understand our data, we have developed a full color map that will take all of our data and integrate it, utilizing an easy to read color scale to make marketing decisions much easier.

For the shipping maps, there are 5 ranges of scores which vary between 0 and 100. Scores between 0 and 20 indicate weather conditions that are very conducive to shipping products between the distribution centers and the individual stores. Scores between 20 and 35 represent good shipping conditions while scores between 35 and 50 represent Ok shipping conditions. Once scores go above 50, shipping can become very dangerous, due to several of the above weather variables, and is not recommended. Scores above 70 indicate that conditions are likely

too dangerous to travel and that another route should be planned or the shipment should be

cancelled. An example of one of these maps is shown below. (See Figure 10)
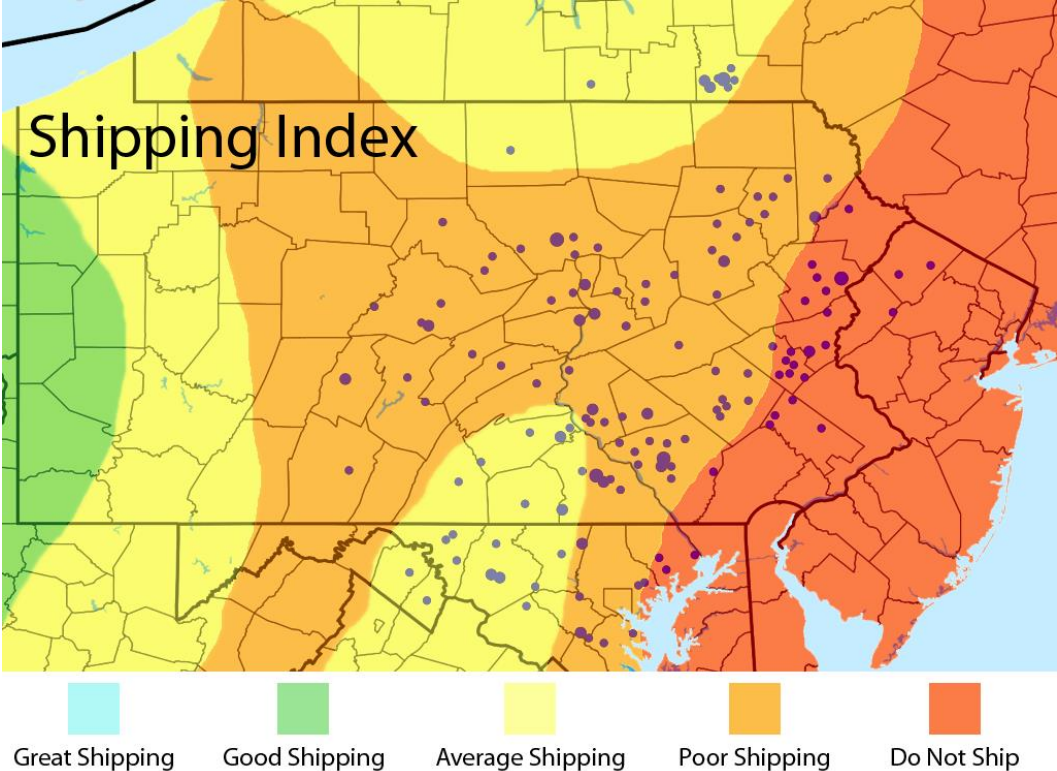

Figure 10

For the sales maps, there are 4 ranges of scores that also range from 1 to 100. Scores

below 20 indicate that sales are likely not going to be very high and that the company may want

to consider having fewer employees working and or ordering less product. Scores between 21

and 50 indicate that sales will be relatively normal. Scores between 51 and 75 represent above

average sales, likely due to an impending event. This suggests that the company may want to

make sure that there are plenty of employees working and that there is enough stock to supply

the demands of the consumers. With scores above 75 Weis can expect to be very busy with lots

of customers wanting all kinds of different goods, especially staples such as bread, milk and

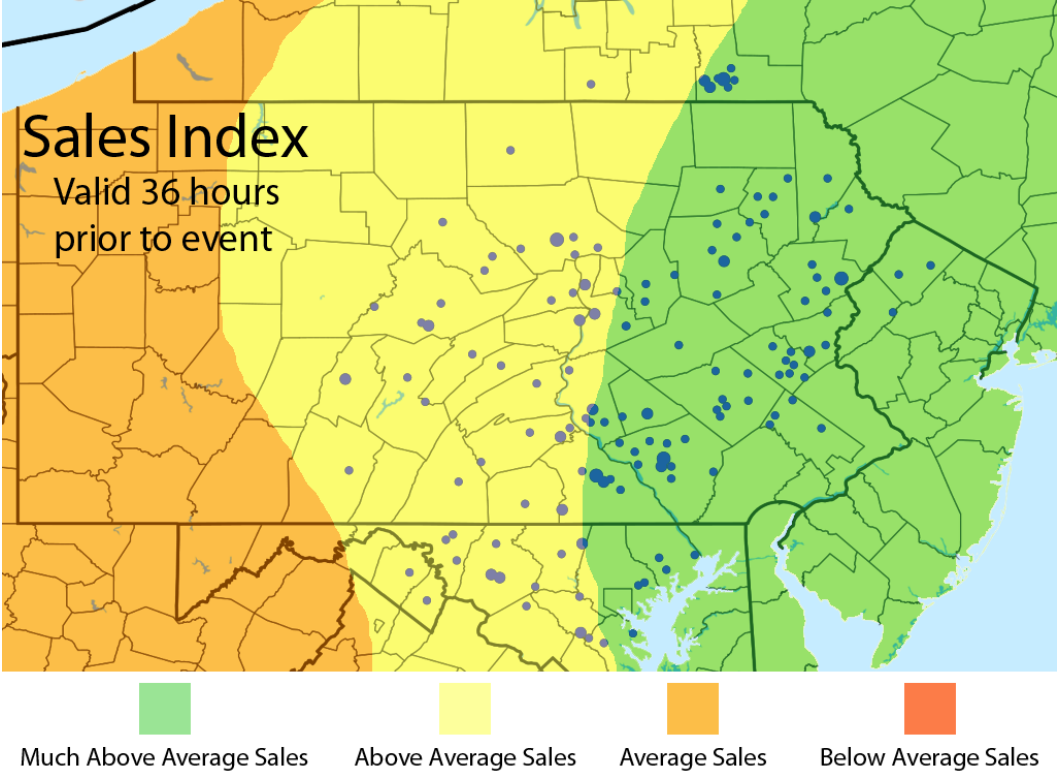eggs. An example of one of these maps is shown below.

Figure 11

Appendix (Wx Index – Shipping)

Temperature Add ____ to base	
If temp < 32°	2
If 28°< temp< 36°	5
If temp < 15°	10

Probability of Precip Add _____ to base	
0-30%	0
31-50%	2
51-75%	5
76-90%	7
91-100%	10

If Precip Type Is ____, multiply PoP value by	
Rain	1.5
Snow	3
Sleet	3.5
Freezing Rain	5

Wind Speed Add _____ to Base	
Calm - 25 mph	0
25-40 mph	5
> 40 mph	10

Cloud Cover- If ____ Then, Subtract ____ From Base	
0-25%	10
25-50%	5
50-75%	3
75-100%	0

Visibility - If Visibility is ____ Then Add ____ to Base	
7-10+ miles	0
4-7 miles	3
1-4 miles	7
.5 - 1 mile	10
< .5 miles	13

Amout of Driving Time Add ____ to Base	
< 11 hours	0
11- 13 hours	1
13 - 15 hours	3
15 - 18 hours	5

Average Scenario	
Base	10
Temp - 12°	22
60% Chance of Snow	37
Winds ~ 30 mph	42
Cloud Cover 10%	32
Visibility ~ 6 miles	35
Time - 12 hours	36

Worst Case Scenario	
Base	10
Temp - 12°	22
100% Chance of FzRn	72
Winds ~ 50 mph	82
Cloud Cover 100%	82
Visibility ~.25 miles	95
Time - 16 hours	100

Departure from Normal Temperature			If _____ is forecasted subtract _____ to base number			If __ hours till event, Multiply by __	
>50⁰ colder	-30		>1" of Snow	1		> 48 hours	3
40-50⁰ colder	-20		1-3" of Snow	3		48 -36 hours	4
30-40⁰ colder	-15		3-6" of Snow	5		36 -24 hours	5
20-30⁰ colder	-10		6-9" of Snow	6		24 -18 hours	4
10-20⁰ colder	-5		9-12" of Snow	8		18 -12 hours	3
< 10⁰ colder	0		12" + of Snow	10		12 - 6 hours	2
< 10⁰ warmer	0					< 6 hours	1
10-20⁰ warmer	5		Glaze-.1" of Ice	5			
20-30⁰ warmer	10		.1-.25" of Ice	8			
>30⁰ warmer	15		> .25" of Ice	10			

Appendix (Wx Index – Shipping)

Average Scenario for Sales			Worst Case Scenario For Sales			Best Case Scenario For Sales	
Base	30		Base	30		Base	30
3-6" of Snow w/ 20 hrs till event	50		.5" of Snow w/ < 6 hrs till event	31		12+ " of Snow w/ 36-24 hrs till event	80
10-20⁰ colder	45		> 50⁰ colder	1		> 30⁰ warmer	95