University: University of Miami

Name of University Researcher Preparing Report: Katrina L. Frank

NWS Office: Glasgow, Montana

Name of NWS Researcher Preparing Report: Tanja E. Fransen

Partners or Cooperative Project: Partners Project

Project Title: The feasibility of an extreme cold warning system

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PROJECT OBJECTIVES AND ACCOMPLISHMENTS

The general scope of the project was to:

1. Determine the feasibility of the use of an automated synoptic index (the spatial synoptic classification or SSC) in the development of extreme weather warnings, based on negative human health outcomes, in small communities.

2. Determine the feasibility of developing SSC-derived cold/health warning systems and evaluate the utility of such systems for other concerns that relate to extreme weather, such as agriculture or water resources.

In past several months a group of NWS Glasgow employees (Tanja Fransen, Corey Bogel, Don Simonsen, and Tom Salem) and Dr. Larry Kalkstein, University of Miami, have met several times via conference calls and examined the possibility of a cold warning system for cattle and a human heat warning system for rural areas. We have also added Dr. Katrina Frank, Synoptic Climatology Laboratory, to our team.

Heat Warning System

Unlike previous health warning systems for metropolitan areas, the data on negative health outcomes in rural areas are not as prevalent and do not allow for statistical comparisons between the mortality and the synoptic-scale pattern. In an effort to develop a surrogate dataset that was of sufficient size, Dr. Kalkstein and his colleagues looked at the human mortality data for larger communities that might have a similar climate as Glasgow: Bismarck and Fargo, North Dakota. The dataset for these two cities was still too small and the comparison with the synoptic pattern did not lend itself to any conclusions.

However, other work by Watts, Sheridan, and Kalkstein (2004) showed the possibility of clustering large metropolitan cities based on a climatological stress index for humans. Using this as an example, research was conducted to show that mortality response to hot weather is somewhat regionally cohesive. Also, using the Spatial Synoptic Classification (SSC), which is the meteorological input for all of our existing heat/health warning systems, the team determined that regions exhibit similar frequencies of air-mass types. Over 10 regions were identified for the United States and southern Canada (Figure 1), and it is clear that, from an air-mass standpoint, there are cohesive regions. This implies that mortality response is similar across regions and we suggest that it is feasible to develop a heat/health watch-warning system for WFOs serving smaller populations by using the observed mortality response from a larger metropolitan area in the same air-mass region.

Using this method, we believe that it is feasible to develop the first-ever human heat/health warning system for a small community or rural areas. It is expected that the methodology could easily be expanded beyond northeast Montana.

Cold Warning System

Our group determined that there was not enough human population in northeast Montana or the northern plains to develop statistics for a human cold warning system. Efforts were thus concentrated on a cold warning system for livestock. There are data on livestock mortality collected by the State of Montana and the U.S. Department of Agriculture. However, these data were generally not useful because of the lack of detail in time of death–monthly and yearly data do not lend themselves to developing a daily warning system. In order to acquire data on a finer temporal scale, and to learn what type of warning system the ranchers would find most useful, i.e., adult cattle or calves, the NWS office developed a questionnaire for local ranchers. The questionnaire identified weather events that caused problems for livestock and the amount of time needed to help protect and care for the livestock. The 19 returned questionnaires showed that the primary concern for the ranchers is newborn calves; one rancher stated "calves are our saleable product, so no calves, no sales, no income." Based on the results of the questionnaires, the team narrowed the focus of this project to a cold warning system for newborn calves, specifically those less than 24-hours old because these calves are least able to regulate their body temperature (Sanko et al. 1991).

An SSC-based system, like those developed for humans exposed to heat, requires a large mortality dataset. The 19 questionnaires did not yield a sufficiently large dataset to develop such a system. They did, however, provide insight into the specific meteorological conditions that result in widespread calf deaths and the team decided to pursue the possibility of developing a warning system based on these criteria and on data described in the literature, rather than on a synoptic index (Figure 2).

Suggested threshold temperatures (expressed as wind-chill temperature to account for the combined effect of cold and wind) for calf stress were extracted from a review of the literature. It is widely accepted that the lower critical temperature, the temperature at which the animal begins to experience cold stress because it "must increase its rate of metabolic heat production to maintain homeothermy" (NRC 1981, p. 9), for newborn calves is 48.2°F (9°C) (Webster 1974; NRC 1981; Ames 1988). This threshold was deemed too warm to accurately express the temperature at which calves might begin to experience significant negative health effects resulting from cold exposure, particularly in eastern Montana. Instead, 41°F (around 5°C) was selected as the threshold for the lowest level of advisory based on the fact that many workers (i.e., Sanko et al. 1991; Josey et al. 1993; Dietz et al. 2003; Riley et al. 2004) exposed calves to this temperature to in studies of the animals' responses to cold conditions or identified this as a temperature at which calves began to exhibit signs of cold stress. A 2-hour duration of exposure to temperatures below the threshold was selected as necessary for the next level of advisory based on the work of Dietz et al. (2003) who placed 6.5-hour-old calves in a cold chamber and measured the animals' level of shivering after prolonged exposure. The plot of calves' degree of shivering versus time in the cold chamber was asymptotic at about 60 minutes of exposure, suggesting that the animals had reached the maximum level of stress they would experience at that temperature. 32°F was selected as the threshold temperature for the next level of advisory based on Oklahoma State University's Cattle Stress Model (Lalman et al. 2003). Precipitation was identified as a factor that increases the level of cold stress an animal experiences at a given temperature by many workers (Ames 1988; Lalman et al. 2003). This is because wetness causes increased heat loss through evaporation and negates the insulative properties of the animals' hair coat. Finally, a 24-hour temperature range greater than 30°F was generally characteristic of the calf-death events producers identified on the questionnaire and was selected as a factor for discriminating the very highest level of advisory.

The raw variables incorporated in this system are generally similar to those used for previously-developed human-health warning systems: air temperature, wind speed and precipitation. A variable that has been identified as important for those human systems is the consecutive-day count. That is an indicator of the length of time the oppressive conditions have been ongoing and is also important to consider when creating a warning system for animals, however, since newborn calves were not exposed to the previous environmental conditions (their previous environment has been controlled by their mothers) this is not an important consideration in the development of this system.

SUMMARY OF BENEFITS

This study has increased the level of interaction between the WFO and ranchers in the area; who have provided information to the office on how they are using our forecasts. This has helped the office improve the forecasts and even include information specifically for ranchers in outlooks.

This work has been key in moving the University of Miami into the active realm of the development of heat/health warning systems. The collaboration has introduced many of the University of Miami faculty to an avenue of work they had not dealt with before and has allowed students in the Department of Geography and Regional Studies to observe aspects of the development of a new heat/health system.

This study has found that both the development of a heat/health watch-warning system for a small-population WFO and the development of a cold warning system for calves are feasible and desired by the community.

PRESENTATIONS AND PUBLICATIONS

The results of the regional analysis of mortality response to hot weather were presented at the 87th Annual Meeting of the American Meteorological Society in San Antonio, Texas, in January 2007.

The results of the feasibility study for development of the calf cold warning system is on the program for the 88th Annual Meeting of the American Meteorological Society in New Orleans, Louisiana, in January 2008.

It is anticipated that a peer-reviewed article outlining the feasibility and development of the calf cold warning system will be submitted if the second phase of the project (the actual development and implementation of the system) is funded.

RELATED ACCOMPLISHMENTS

The project will be briefed at the NWS Great Divide Workshop in Oct 2007.

Tanja Fransen briefed the Weather and Society: Integrated Studies (WAS*IS) group about the project.

Local emergency managers and public health officials were briefed about the project and they provided a positive response as to the need for both systems.

SUMMARY OF PROBLEMS ENCOUNTERED

No problems were encountered during the human heat/health feasibility study.

A lack of knowledge of how livestock interact with the weather was solved by talking to the local ranchers and having Dr. Katrina Frank join our team.

As discussed above, a limited amount of livestock mortality data are available.

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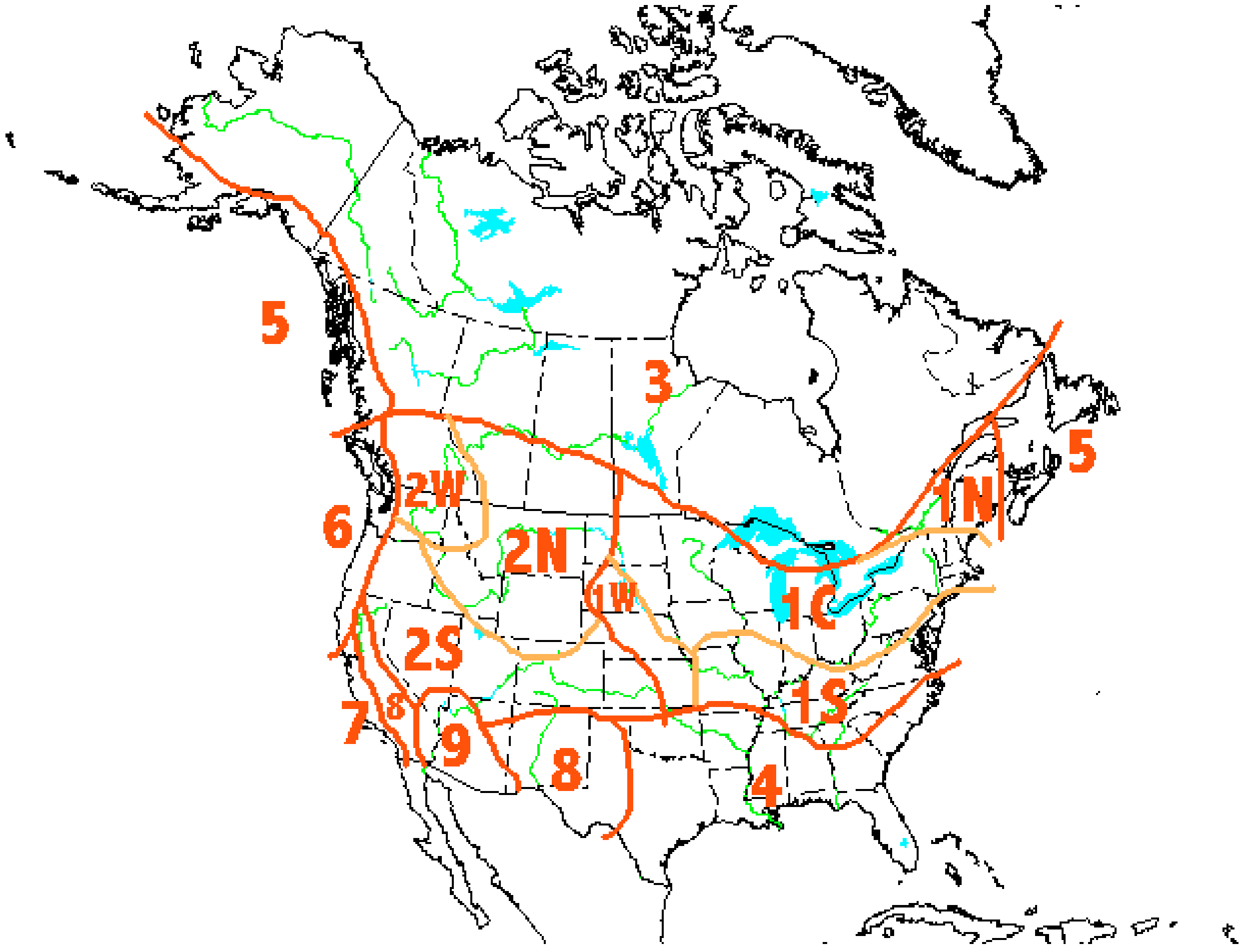

Figure 1. North America may be divided into regions exhibiting similar air-mass frequency.

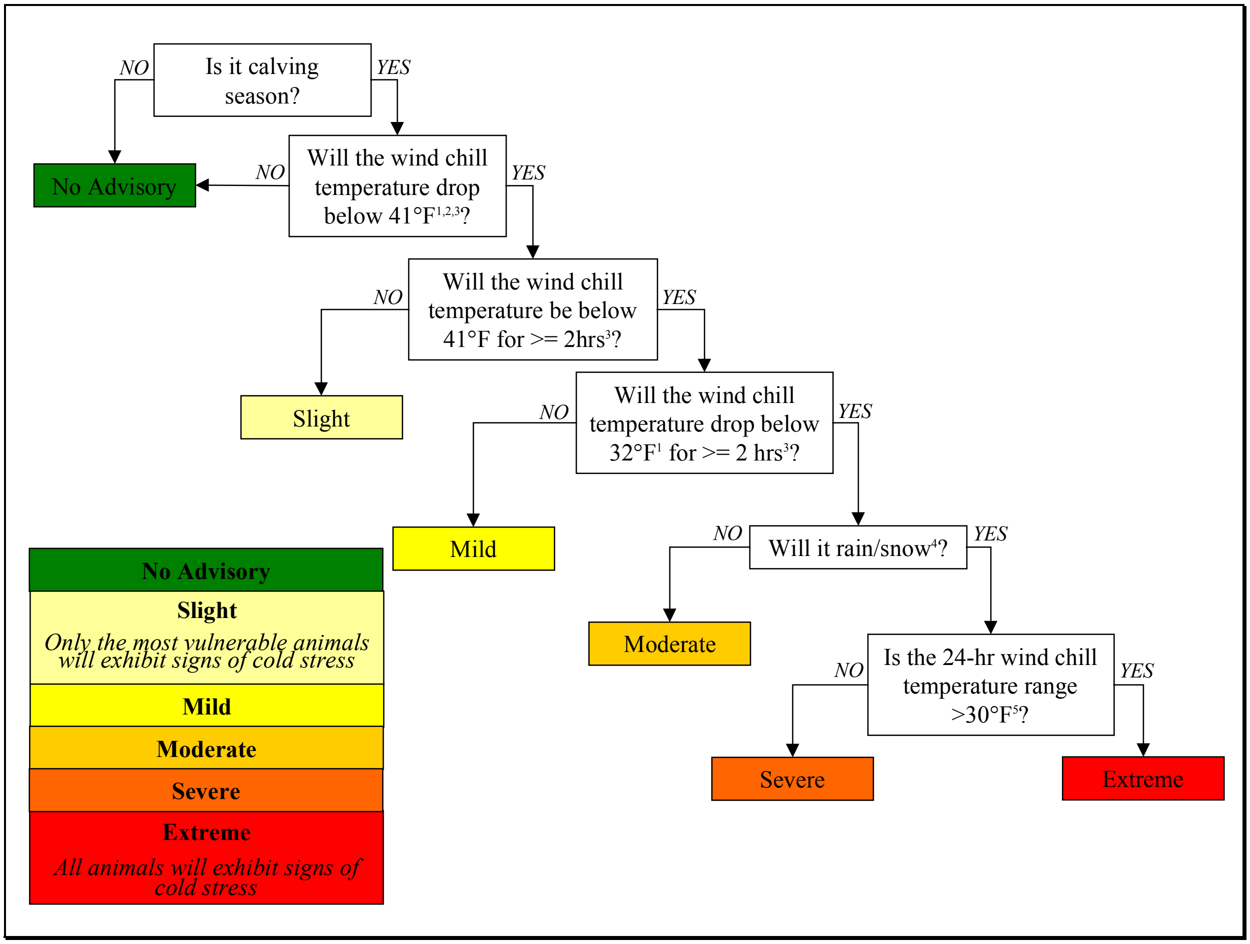

Figure 2. Proposed decision tree for calf cold advisory system.