COMET Partners Program Final Report

Nocturnal Convective Development in South Dakota

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Section 1: Summary of Project Objectives

1. Create a "climatology" of storm nights of nocturnal convection in South Dakota and vicinity based upon National Lightning Detection Network (NLDN) criteria.
2. Find favored areas of lightning development and lightning propagation for both severe and non-severe storms.
3. Use composite analysis to determine the synoptic and sub-synoptic scale forcing for both severe and non-severe thunderstorm events.
4. Apply results of both climatology and compositing to better forecast development, intensification, and propagation of both severe and non-severe nocturnal storms in the Sioux Falls County Warning Area.

Section 2: Project Accomplishments/Findings

For the years of 1998-2003, composite lightning analyses were performed on a 0.25^{o} latitude by 0.25^{o} longitude grid over the domain outlined by 101^{o}W to 94^{o}W longitude and 42^{o}N to 46^{o}N latitude to determine nocturnal convective storm days. A storm day was defined as a period during which a coherent NLDN lightning pattern (10 flashes per hour within a 0.75^{o} by 0.75^{o} box) developed within the area of analysis with the first hour occurring between 0200 and 1400 UTC. The storm days were then stratified into severe storm days and non-severe storm days using the **Storm Data** archive. A severe storm day was defined as having 3 severe reports or one tornado report in the same or adjacent counties during a one-hour period.

An examination of data showed there were two peaks for initiation of convection over the area – one around 0400 UTC and the second centered on 0800 UTC. South central South Dakota was a relative maximum for development of convection while southwest Minnesota was a relative minimum for development.

Composite upper-air analyses were performed for the severe storm night subset using the NCEP reanalysis data set for the dates described above. Composites were computed for all dates, Overall, nocturnal convective development occurred just as a long-wave ridge had moved east of the forecast area. This was to the south of the 300 mb jet stream and was at the nose of the 850 mb low-level jet. The area was at the northeastern edge of the mid-level capping inversion – defined as 10^{o}C at 700 mb. Finally, the area was also at the northern end of a low level moisture surge.

In addition to composites for all cases, composites were computed for severe dates and non-severe dates with difference fields were computed between the two means. It was found that severe cases were associated with a stronger mid-level ridge over the Great Lakes and a stronger trough over the western United States. Severe cases were associated with a stronger low-level jet across the central and southern plains with more moisture over the area of interest. Finally, the 700 mb temperature was warmer for severe

cases while the 500 mb temperature showed little difference. This suggests that severe cases are associated with a more unstable elevated mixed layer.

Section 3: Benefits and Lessons Learned: Operational Partner Perspective

This research showed how common nocturnal convective development was across the eastern portion of the northern plains. Based upon our findings, we learned that during the warm season, nocturnal convection develops approximately once every 5 days and severe nocturnal convection occurs approximately twice per month. We also learned of the existence of the NCEP reanalysis data which allowed us to quickly create composites of height, moisture, and wind from the lightning data. We have created numerous composites which forecasters can use for identifying favorable patterns for convective development. These composites will be placed on an internal web page for forecaster reference during the next convective season. This will provide forecasters with greater confidence in forecasting nocturnal convection and better identify days where convective development is likely versus those where development is unlikely. As WFO Sioux Falls continues to apply this research to the operational forecast desk, improvements in probability of precipitation forecast, expectations for severe weather development, and timing of precipitation will improve.

Finally, this grant provided a beginning to improvements in nocturnal convection. This research has motivated at least one forecaster to continue the research begun in this grant. After completing the research there were many questions as to the mechanisms which result in nocturnal convection. By providing a data set with no convection, non-severe convection, and severe convection, continued research will be done to continue to improve forecasts and understanding nocturnal convective development. It is the hope of NWS Sioux Falls that this research can be done in collaboration with Saint Cloud State.

Section 4: Benefits and Lessons Learned: University Partner Perspective

The primary benefit from this project was the professional development of Matthew Dux, the Saint Cloud State University (SCSU) student who was the primary student researcher on this project. The bulk of the grant funds were used to hire Dux full-time during the summer of 2004 at NWS Sioux Falls. Dux performed most of the lightning and composite analyses until his graduation in December 2004. The experience Dux gained and the strong recommendation provided by NWS Sioux Falls personnel has led to his employment at NWS Pleasant Hill, MO.

Nocturnal convection has been a primary research interest of Robert Weisman since arriving at SCSU. Several local senior research projects have attempted to determine a climatology of nocturnal convection, but failed to diagnose possible mechanisms. The funding of this project advanced my understanding through the identification of potential mechanisms. Such conclusions are of great interest to regional National Weather Service Offices, whose forecasters have long identified nocturnal convection as both a forecasting and public alert problem. The communication of these results at a regional NWS conference and the National Weather Association Annual Meeting will continue to allow research results to improve local forecasts.

This project provided a continued platform for interaction between NWS Sioux Falls and Saint Cloud. This interaction will continue with worked planned on the problem of capping inversions inhibiting Northern Plains convection. Other interaction has included the identification of research projects for use in SCSU class projects and senior research. The close relationship has also allowed early identification of student employment opportunities such as the SCEP and STEP programs. Successful completion of these programs has ensured that a steady stream of SCSU graduates have moved into the National Weather Service.

Since the lightning data were provided by Dr. David Schultz (CIMMS/NSSL), this project opened the door to possible collaboration between SCSU and NSSL. This resulted in Dr. Schultz presenting a seminar at SCSU, the first time that an NSSL researcher had ever presented in Saint Cloud. In addition, there have been interactions on potential research projects.

Unfortunately, the questionable funding status for the COMET Outreach Program is a major obstacle to continued collaboration efforts.

The main problem has been to find housing for SCSU students while working at NWS Sioux Falls. The relatively slow Sioux Falls economy allowed Dux to find housing rather easily. This has not been the case for students working on previous grants. Early identification of these students and having them begin the housing search as early as possible should help to make these transitions easier in the future.

Section 5: Publications and Presentations

9th Annual Northern Plains Convective Workshop – Minneapolis, MN (March 2005)
25th National Weather Association meeting – Saint Louis, Missouri (October, 2005)
10th National Weather Association Severe Weather Conference – Des Moines, Iowa (March 25, 2006)

Section 6: Summary of University/Operational Partner Interactions and Roles

Saint Cloud State University (SCSU) and NWS Sioux Falls interacted mainly through the hiring of Matthew Dux, an SCSU senior student, to perform the research. Dux was employed through the project funds to work during the summer of 2004. Dux also performed the research as part of his senior research requirement at SCSU.

In addition, both SCSU and NWS Sioux Falls continue to collaborate on this research with authors representing both institutions at conferences.

The addition of Dr. David Schultz added a new voice to the discussion of Northern Plains forecast problems. Not only was insight on this and other projects added, but also a guest seminar was provided to both NWS Sioux Falls and SCSU.

Future and current research projects continue to be identified through the continued collaboration between the partners.