CSTAR Final Report
Award: NA16NWS4680008
1 May 2016 - 30 April 2019

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Key Scientific Accomplishments

The following are completed and ongoing tasks associated with this project:

1. We have a completed end-to-end analog-based severe probability guidance system. The system consists of two steps:
   (a) Identification of past environments similar to a forecast (i.e., analogs)
   (b) The development and application of a logistic regression model build from the analogs identified in step (a).

The code has been applied to 30 cases that were provided by NWS collaborators using the ESRL GEFS reforecast data. An example of the severe weather probability guidance and the SPC severe weather reports for the 26 March 2016 event is shown in Fig. 1. The full set of events are available on the web and through our Vlab site. The list of cases and their results can be viewed at:

`http://www.eas.slu.edu/CIPS/SPG/Cases.php`

2. The logistic regression results of 30 spring-time cases were analyzed to identify the top discriminating fields (an example is shown in Fig. 2). This was the focus of Master's student Kyle Perez. The results indicated that the mass fields were the mostly common top discriminating fields.

3. A second system was developed to run in near real-time. The real-time system currently compares the average of the real-time GEFS members to the average GEFS historical reforecast data from ESRL. This system runs once a day using the 0000 UTC GEFS model run and creates probabilistic guidance from day 1 to day 8. It is available online:

   `http://www.eas.slu.edu/CIPS/SVRprob/SVRprob.php`

4. The real-time system was adapted to include hazard-specific probability guidance (i.e., wind hail and tornado). It also available at the above web site.

5. The real-time system will shortly include a running assessment of the guidance using reliability diagrams. It will display reliability diagrams for the last 7, 14, 30, and 60 days. Issues with coding have delayed its implementation, but will be made available through the same web page.

6. The guidance methodology was adapted to produce snowfall probability guidance. This was beyond the initial scope of the project and was completed by Master's student Matt Flanagan. The interest in the NWS to product probabilistic snowfall guidance was the driving force for this effort. The results suggest the system has skill for low snowfall totals (i.e., accumulations less than 4 inches). However, there is substantial "under forecasting" for higher snowfall amounts (Fig. 3). The reliability diagram indicates that the guidance has poor resolution for higher snowfall amounts (i.e., higher guidance probabilities are not associated with higher observed probabilities).

7. After the analysis of the 30 cases and running the real-time system for over one year, there were several issues that became apparent (see **Lessons Learned**). Consequently, several changes to the methodology were investigated including:

   - The regression model at each grid point is constructed only if there are at least 10 analogs out of the top 100 that contain severe weather reports. This removes isolated unreasonable results (i.e., noise) when there are too few reports.
   - We adapted the methodology to compare the GEFS average and members to the North American Regional Reanalysis (NARR; rather than the reforecast GEFS). The motivation for this includes: 1) the NARR has a longer period of record and 2) with future

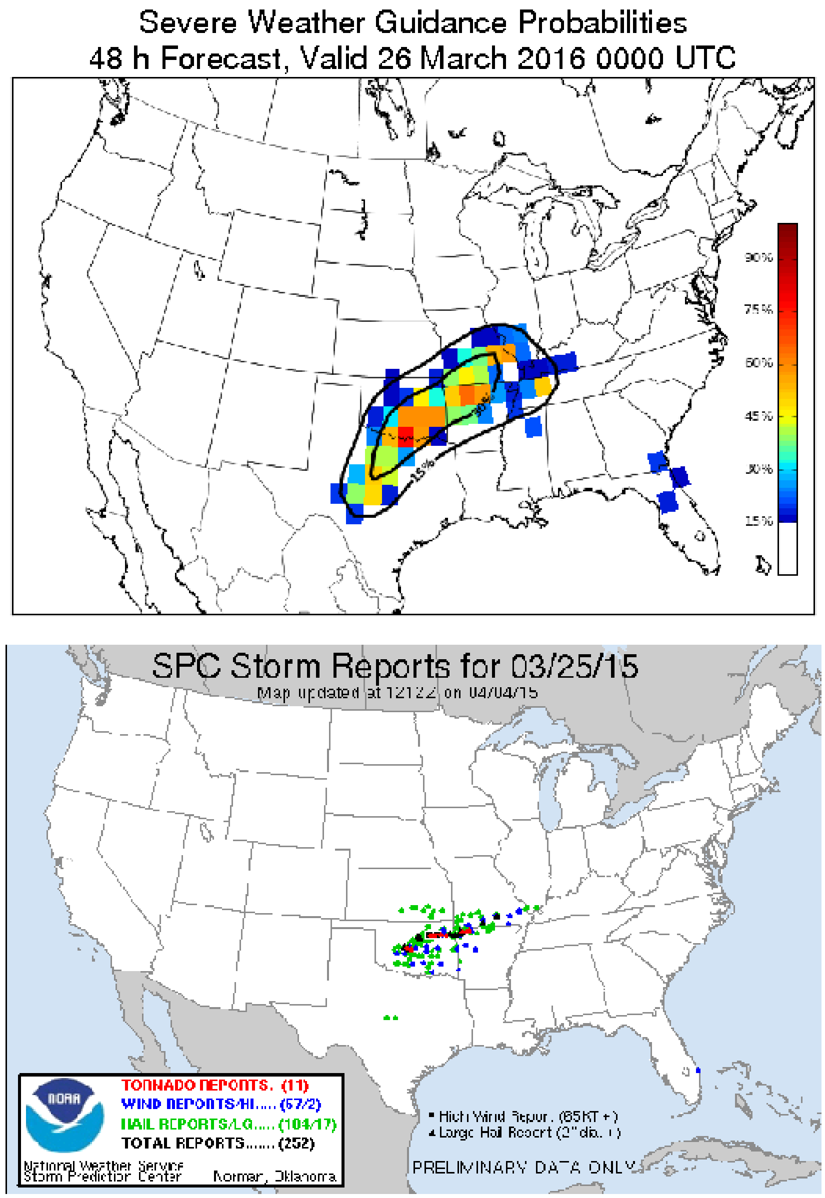

Figure 1: Severe probability guidance and SPC storm reports for the event on 26 March 2015

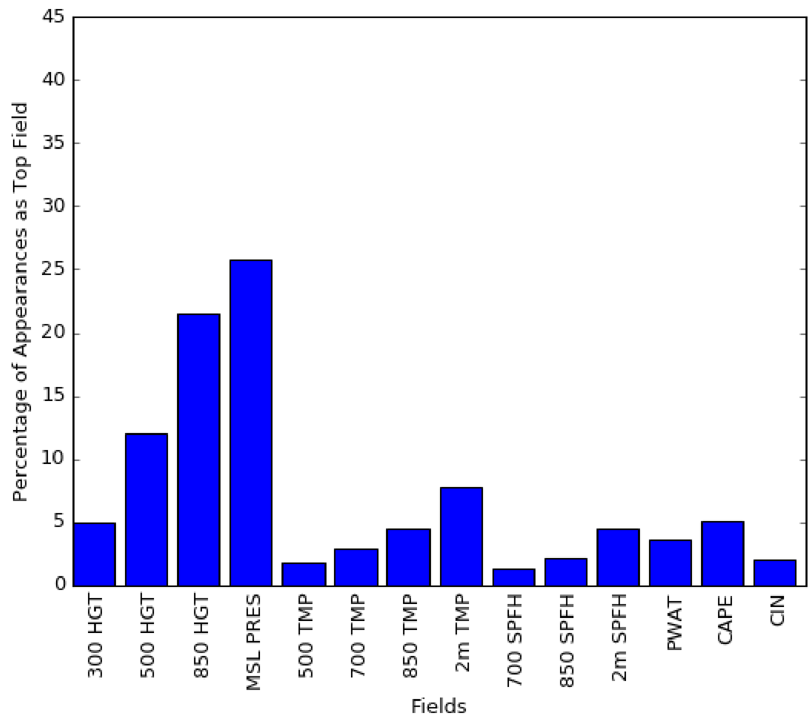

Figure 2: The percentage of each regression predictor as the top discriminating field for 30 spring-time cases.

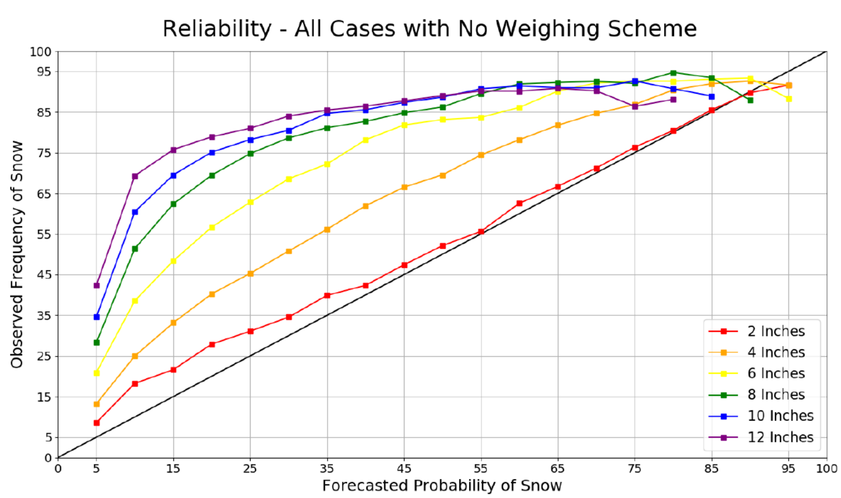

Figure 3: The reliability diagram of analog-based snowfall guidance from 30 Midwest snowfall events.

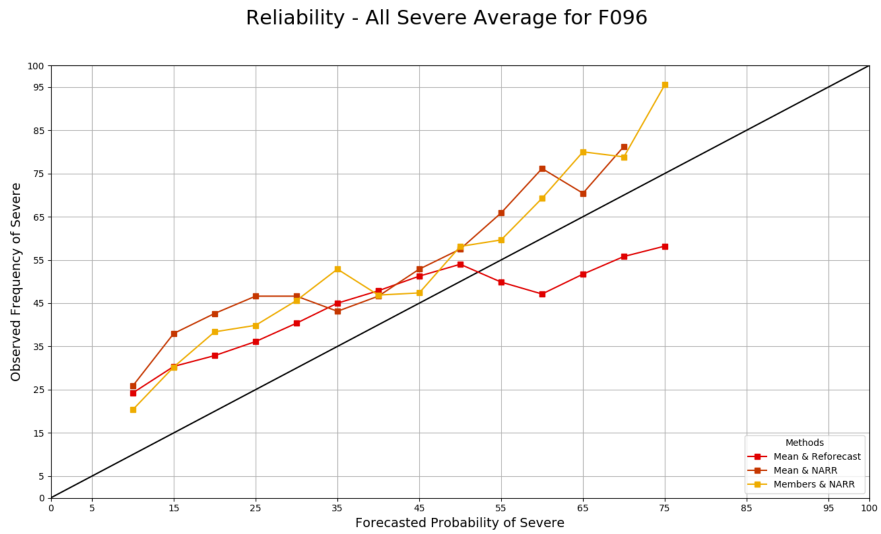

Figure 4: The reliability diagram of analog-based severe guidance from selected cases for the 96-h forecast. The legend denotes the three methods 1) GEFS mean compared with the mean GEFS reforecast, 2) The GEFS mean compared with the NARR, and 3) the GEFS members compared with the NARR.

upgrades (i.e. FV3) a comparable reanalysis may not be available. The reliability diagram indicates the results are comparable or even better that in initial methodology (see Fig. 4 for sample results).

- We expanded the search for analogs to hours other than 0000 UTC. The initial approach only consider analogs at 0000 UTC. By including 0600, 1200, and 1800 UTC the overall analogs improved (based on analog scoring metrics). However, the most common top matching analogs occurred at 0000 UTC. Additionally, the probability guidance improved as assessed through on reliability diagrams.
- We developed a version of the system that applies the methodology to each individual member of the GEFS (rather than the average) and searches for analogs from the NARR. This is approach is able to examine the spread in guidance. Figure 5 illustrates the potential spread of probabilities for the 28 April Southeast Outbreak for the 96-h forecast from the individual GEFS members.

Lessons Learned

1. Throughout the cases and real-time runs, the performance of the guidance tends to be poor in summer situations. The system is dependent on synoptic-scale patterns and those tend to be weak in the summer. Some performance improvement was seen with altering the logistic regression conditions for a severe weather ”hit”.

2. For severe weather events, the probability guidance had a significant ramp up of probabil-

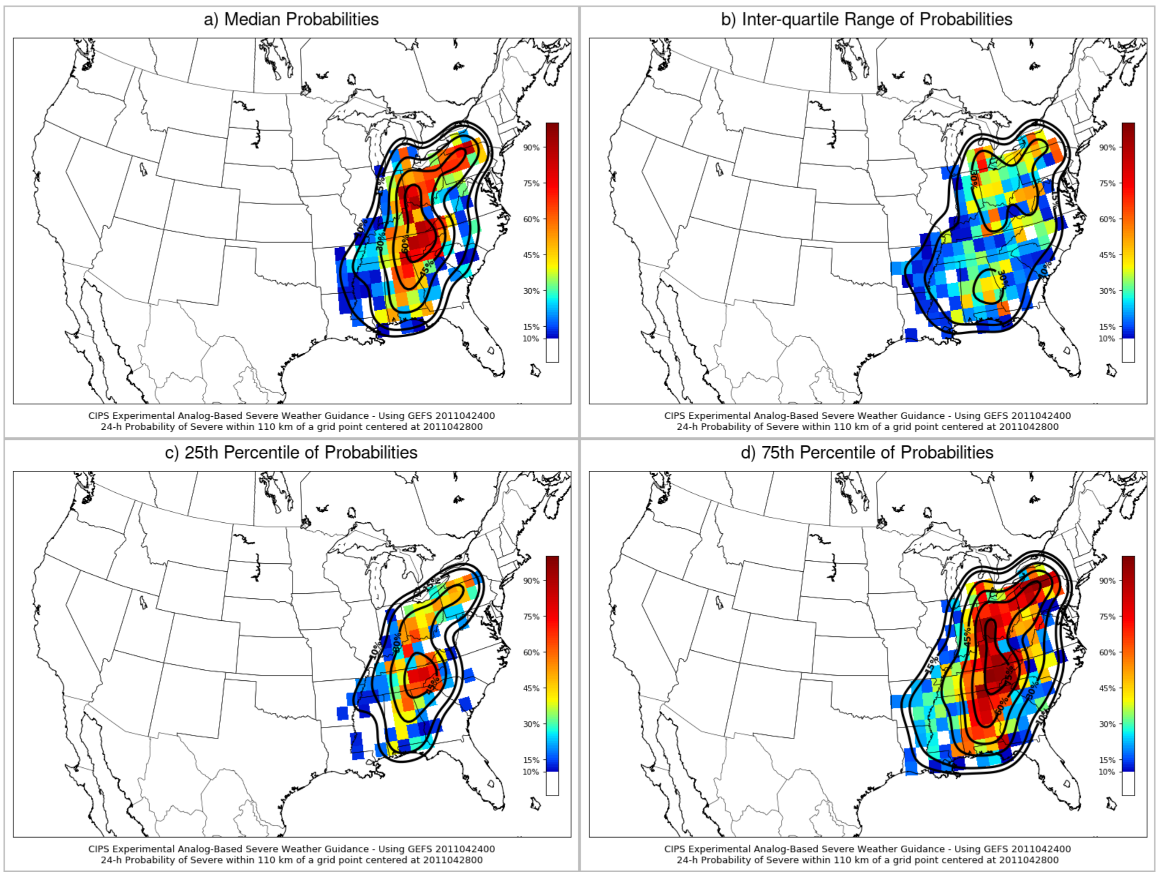

Figure 5: An example from 28 April 2011 of the possible probability guidance products using the individual members of the GEFS forecast. The products include the a) median, b) spread (IQR) c) 25th percentile and d) the 75th percentile based on probabilities generated from each GEFS member.

ities from forecast hour 192 to forecast hour 24. When using the GEFS ensemble mean at significant lead times, there is often enough variability among members to create a mean that is not indicative of severe weather. Once the members converge to a common pattern, the pattern becomes more indicative of severe weather and the probabilities ramp up. This was noted by several NWS forecasters and prompted us to consider using the individual members, although this effort was beyond the scope of the original proposal.

3. The identification of ”top” analogs was occasionally suspect. In several cases, the 500 mb geopotential heights of the top analogs did not show the obvious features of the forecast (e.g., a negatively tilted trough). Efforts are underway to more closely examine how the top analogs are selected and what changes might produce more consistent ”top” analogs. We suspect that the analog selection process includes too many fields and the process should concentrate on selecting analogs which more closely match the mass fields.

4. The analysis of the case studies, while useful for a pilot study, contained no “false alarms.” However, the real-time guidance was run even on days without severe weather potential and occasionally, on those “severe clear” days the guidance would still generate probabilities upwards of 30%. We suspect this is closely coupled with the selection of analogs mentioned above.

5. While the guidance has been useful to NWS forecasters, there has also been requests to provide information on the ”top” analogs. Forecasters have noted that identifying similar past cases is useful for IDSS. They mentioned that communicating forecasts with the public and providing context by comparing to past events can be effective approach.

Interactions with NOAA Scientists

As noted above we have had numerous discussions with NWS forecasters. Regular conversations throughout the project occurred with Jim Sieveking (SOO, LSX), Fred, Glass (Lead, LSX), John Gagan (SOO, MKX), and Chad Gravelle (SRH) on progress and evaluation of the severe weather guidance.

We traveled to SPC and talked with their forecasters. We discussed their forecast difficulties and approach. Those interactions altered our real-time system to provide guidance at days 3 and 4 first. This guidance was considered more critical and would be most useful to the over-night shifts at SPC.

The PI (Charles Graves) presented at the SOO Development Workshop in Kansas City, in the August of 2017. Additionally, he presented at the NWS Central Region Southeastern SOO workshop in July of 2017.

Discussions with Todd Lindley (SOO OUN) lead to a completely new project examining wildfire outbreaks in the southern plains using the tools developed for the severe probability guidance. This project is currently being proposed for a COMET partners project.

Progress Against Milestones

Most of the projects milestones where accomplished. An analog-based severe probability guidance system is currently running and providing guidance. It has been used by several forecast offices and has been presented during NWS Central Regions' Regional Operations Center morning briefings.

However, there are several milestones that were not met including a role in OPC exercises. The guidance has several small but noticeable issues that need to be addressed. Also the opportunity at OPC did not present itself.

The project investigated several aspects that were considered beyond the scope of the initial proposal. This included testing the guidance using the NARR data and a version of the guidance that included processing the individual GEFS members. Additionally a new collaboration with OUN developed from this effort.

For the foreseeable future, the real-time system will continue to run and improvements will be developed. This will proceed without continued support from CSTAR.

Presentations

Elmore, A., K. Perez, C. Graves, and C. Gravelle, 2017: SLU CIPS CSTAR Severe Probability Guidance, SE SOO Workshop, July 2017

Graves, C. and C. Gravelle, 2017: CIPS Analog Guidance, SOO Development Workshop, August 2017

Elmore, A., K. Perez, C. Graves, and C. Gravelle, 2017: SLU-CIPS Analog-Based Severe Probability Guidance, 2017 SPC

Elmore, A., K. Perez, C. Graves, and C. Gravelle, 2018: Analog-Based Severe Probability Guidance, 2018 NWA Iowa Severe Storm Conference

Elmore, A., 2018: Analog-Based Severe Probability Guidance, 2018 NWA Annual Meeting

Perez, K., 2018: Analysis of the Top Significant Fields in Analog-Based Severe Probability Guidance, 2018 NWA Annual Meeting

Elmore, A., C. Graves, C. Gravelle, and J. Sieveking, 2019: Assessment of CIPS Analog-Based Severe Probability Guidance, 2018 NWA Iowa Severe Storms Conference