JP4.12 USING GRIDDED MOS TECHNIQUES TO DERIVE SNOWFALL CLIMATOLOGIES

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1. INTRODUCTION

The Meteorological Development Laboratory (MDL) currently provides station-based model output statistics (MOS, Glahn and Lowry 1972) snowfall forecast guidance over the contiguous United States (CONUS) and Alaska out through 4 days. This guidance is based upon data from the National Climatic Data Center's (NCDC) Surface Land Daily Cooperative Summary of the Day (COOP) reports (NCDC 2006), and was implemented in its current form in 2003 (Cosgrove and Sfanos 2004). Because COOP sites report only once daily, the resulting MOS forecasts are for 24-h snowfall amounts. For many MOS elements including snowfall, the station guidance is analyzed to generate gridded MOS guidance (Glahn et al. 2009; Gilbert et al. 2009) as part of the National Digital Guidance Database (NDGD) in support of the National Digital Forecast Database (NDFD; Glahn and Ruth 2003). Efforts are underway to improve and update the current MOS snowfall guidance.

Climatology (typically in the form of a monthly mean relative frequency) has proven to be a useful predictor in the development of several MOS elements, most notably in the extended forecast projections. This is especially true for a variable such as snowfall, due to its relatively rare and non-continuous nature in many parts of the U.S. (particularly heavy amounts). However, snowfall climatology is not available at every site used in the MOS station-based development. By developing a grid of climatological relative frequencies for the domain of the development stations, it is then possible to interpolate these values to any station.

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In this presentation, the process for establishing gridded snowfall climatologies are described. Special focus is placed on the techniques investigated and developed for creating these grids. Plots depicting gridded snowfall climatologies are also shown.

2. NCDC COOP STATION SNOWFALL CLIMATOLOGY DATA

NCDC has compiled a wide range of snowfall and snow depth statistics from both COOP sites and first order airport stations, using data from 1948-1996 (NCDC 1998). Included in these statistics are 30-year normals of snowfall for the period 1961-1990. These normals only contain sites which had a long and reliable reporting history and for which at least 15 years of non-missing data were available. Thus, they represent a solid basis for climatology. There were 3295 sites over the contiguous U.S., Alaska, Hawaii, Puerto Rico, and various Pacific Islands used in creating the normals; 3259 of these covered the CONUS and 23 in Alaska, the regions over which MOS snowfall guidance is developed (Figs. 1 and 2). In 2003 when the operational snowfall product was developed, snowfall relative frequencies were not used because they were not available for every MOS site. The updated development will take advantage of this rich climatological dataset, providing relative frequencies for every desired site in the MOS snowfall development.

From the 30-year normals, we were able to obtain mean monthly relative frequencies of 24-h snowfall amounts for various thresholds at each observing site. The thresholds chosen were 0.1" and 2.0", as these are the levels at which the NCDC climatology and standard MOS categorical snowfall forecasts correspond. These two values represent measurable snow and somewhat more significant snowfall, respectively.

3. DERIVING GRIDDED SNOWFALL CLIMATOLOGIES

3.1 *Description of the BCDG Technique*

In an effort to grid climatological snowfall relative frequencies, we apply the same analysis techniques used to create operational gridded MOS forecasts (Glahn et al. 2009). In addition to a standard Cressman-like analysis (Cressman 1959), this technique includes a correction to accommodate variations of a field with elevation. This analysis method, which includes many enhancements over the basic successive correction method, is called "BCDG", named after the persons responsible for its development—Bergthorssen, Cressman, Doos and Glahn.

Briefly, this analysis uses successive corrections to a first-guess gridded field, with four passes over the data. The radius of influence is decreased on each pass in order to better capture more local effects around each grid point. The vertical change with elevation (VCE) adjustment is computed at each station by comparing neighboring values of the same weather element at different elevations. Those VCEs are applied in the analysis to the grid points within the radius of influence at each station.

3.2 *Application to Snowfall Climatology*

Given the relatively dense field of NCDC climatology sites available over the CONUS (Fig. 1), the application of the BCDG technique provides a solid basis for deriving a gridded field of snowfall climatology. We were thus able to successfully grid mean monthly 24-h snowfall relative frequencies for each month for the 0.1" and 2.0" thresholds mentioned in Section 2. Over Alaska, however, the paucity of climatological sites (Fig. 2) as well as the complex terrain there is proving to be a more challenging problem. As a result, efforts are still ongoing to determine the best way in which to employ this methodology over Alaska.

Over the CONUS, a 5-km grid is used with the initial first-guess field set to zero for the snowfall relative frequency. Previous work has shown that the first-guess field has little effect especially over a field with sufficient data density. A variable radius is applied around each grid point, with subsequent passes equal to a fraction of this value. On the first pass over the data, therefore, the initial radius is determined as that which either encompasses 30 stations or 50 grid lengths (~250-km), whichever comes first. The elevation correction is applied on the first two passes only; fully on the first pass and a fraction of this on the second.

Mean 24-h snowfall relative frequency for January for the 0.1" threshold is shown in Fig. 3, with the full BCDG analysis employed. The climatologically expected south-to-north gradient in relative frequency is clearly seen, as are the relative maxima over the Great Lakes, Rocky Mountains, and Appalachian Mountains. For comparison, a BCDG analysis of the same field with no VCE adjustment applied, is displayed in Fig. 4. While this captures the same gross features as the BCDG technique with VCE, note that much of the detail is lost or smoothed out, especially in elevated regions and around the Lakes. However, over more flat regions such as the middle part of the CONUS, both analyses appear rather similar. Thus, the BCDG technique can more realistically capture finer scale features associated with altitude.

As one last example displaying the BCDG analysis, the mean 24-h March snowfall relative frequency (0.1" threshold) is shown in Fig. 5. Similar to the January analysis, one can still clearly see the "relief" pattern associated with elevation. In addition, an overall decrease in coverage and smaller values in relative frequency are seen in March as compared to January, with the exception of some higher elevations in the Rocky Mountains.

4. SUMMARY AND FUTURE WORK

By applying the same techniques used in creating gridded MOS forecasts, MDL was able to generate climatological relative frequencies of snowfall from the NCDC station-based data. These grids can be used in the updated snowfall development, and are expected to play a role in improving the MOS snowfall guidance.

At the time of this presentation, gridded climatologies have been successfully completed for the contiguous U.S. for all 12 months. However, due to the small number of climatological sites available over Alaska as well as the more complex terrain there, we are still working to obtain a realistic climatology over that region. We hope to have this completed by the time the next snowfall development is done.

Beyond its application for snowfall, our work here demonstrates that the methodologies employed in gridded MOS can be used to generate climatology grids of other parameters. Therefore, in addition to being a tool to analyze station-based MOS forecasts onto a grid, it can also be used more generally to analyze observed data, thereby increasing the range of possible high-resolution predictors.

Other future work involves the possibility of providing MOS snowfall forecasts at smaller time intervals (i.e., 6-h), as this may prove quite useful to forecasters. This may involve using existing model data and other MOS forecast fields in connection with the 24-h COOP reports.

In MDL's revision of the snowfall development, we will offer the gridded snowfall climatologies as a predictor in the regression analysis. We believe that this, in addition to using more up-to-date model data, will improve our MOS 24-h snowfall guidance. Our first task is to perform this update for MOS based upon the Global Forecast System (GFS) model, in the short range for all four GFS cycles and through the extended range for the 0000 and 1200 UTC cycles (Dallavalle and Cosgrove 2004a, b; Cosgrove and Dallavalle 2005). Once the GFS MOS snowfall development is completed, we will then upgrade the MOS snowfall guidance based on the North American Mesoscale model (NAM; Gilbert et al. 2008).

5. ACKNOWLEDGMENTS

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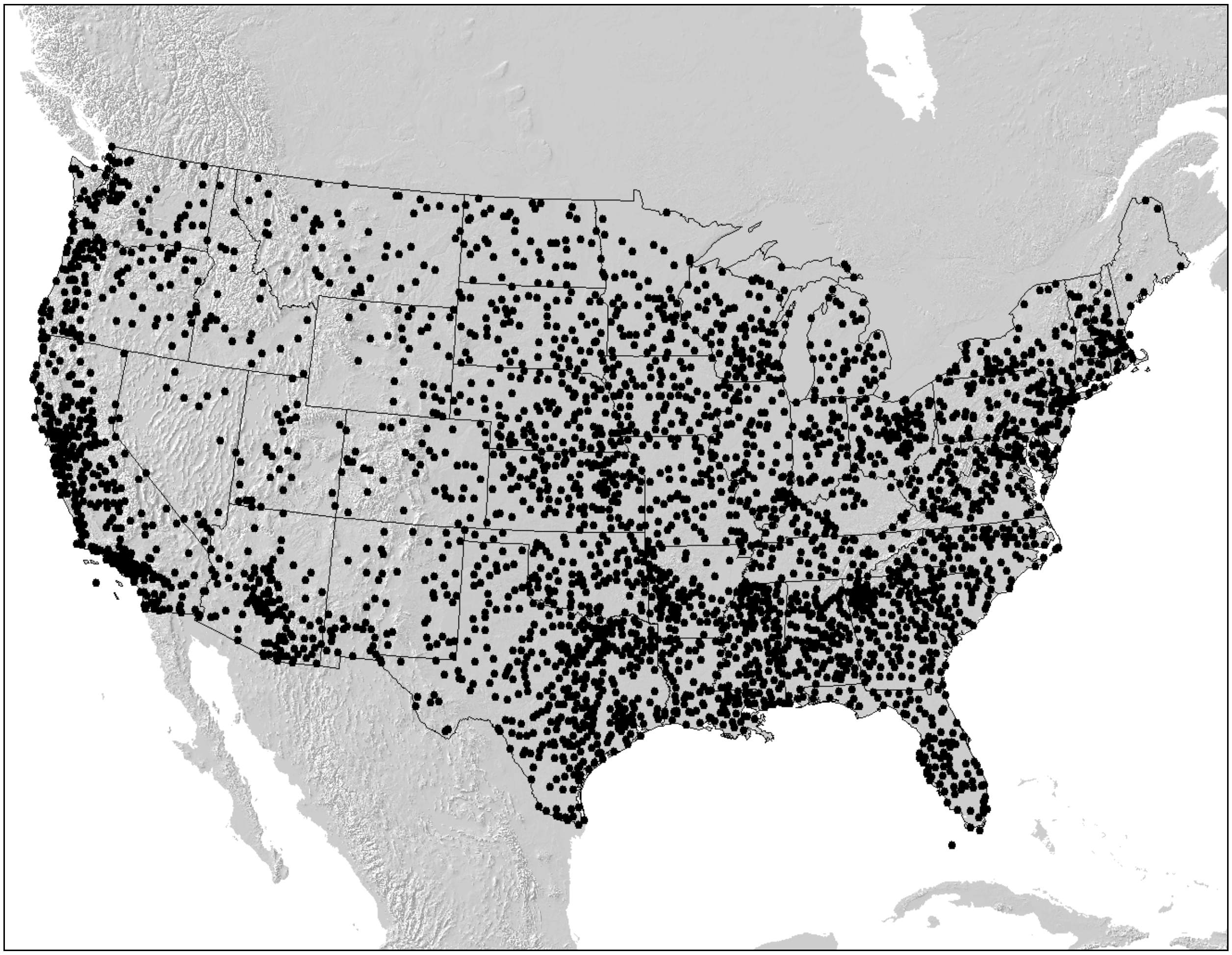
Figure 1. Distribution of the 3259 NCDC sites used for snowfall climatology over the CONUS.

Figure 2. As in Fig. 1, but for the 23 Alaska sites.

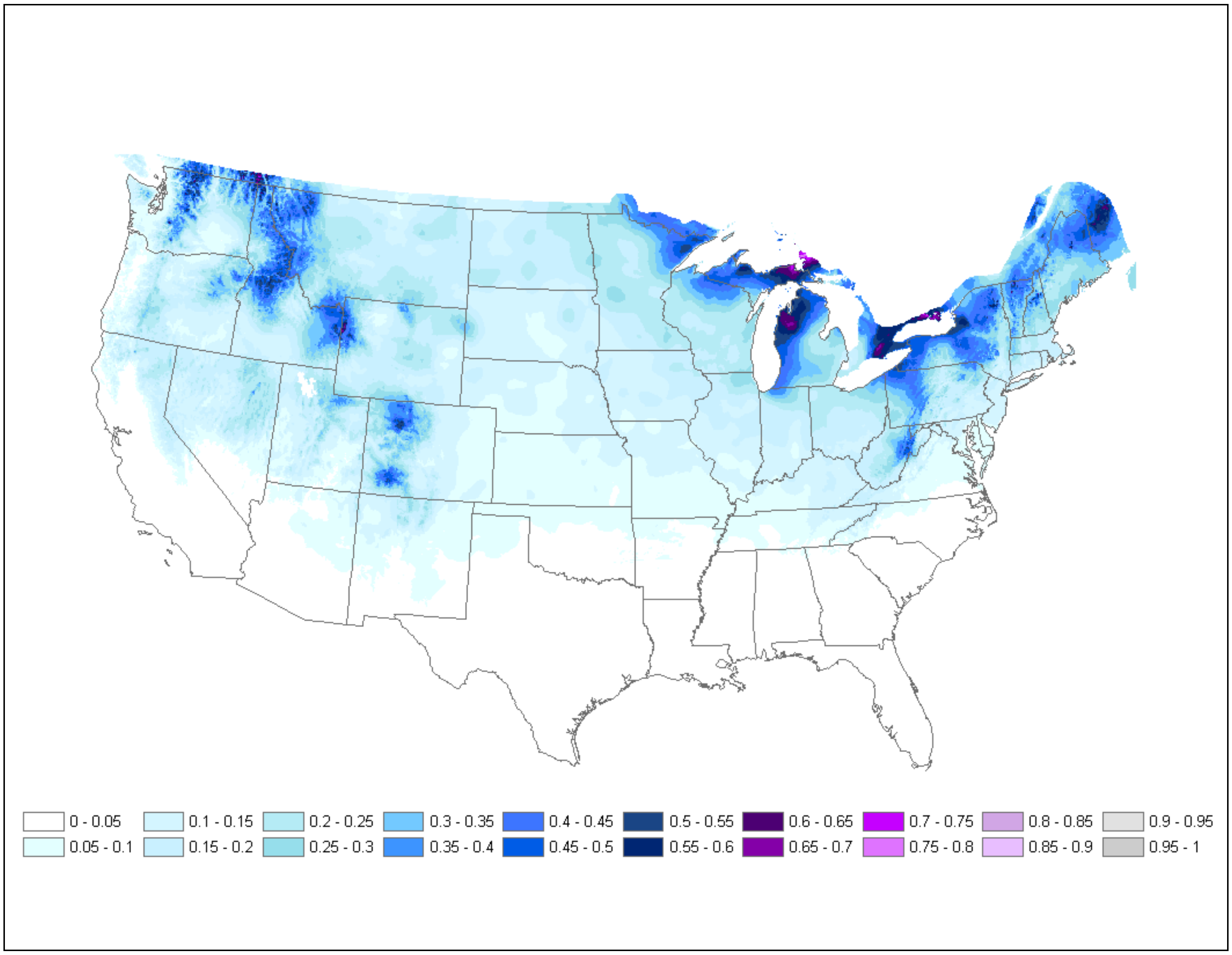

Figure 3. Mean January 24-h snowfall relative frequency for the 0.1" threshold. Full BCDG scheme applied, with VCE adjustment. Color scale is below map.

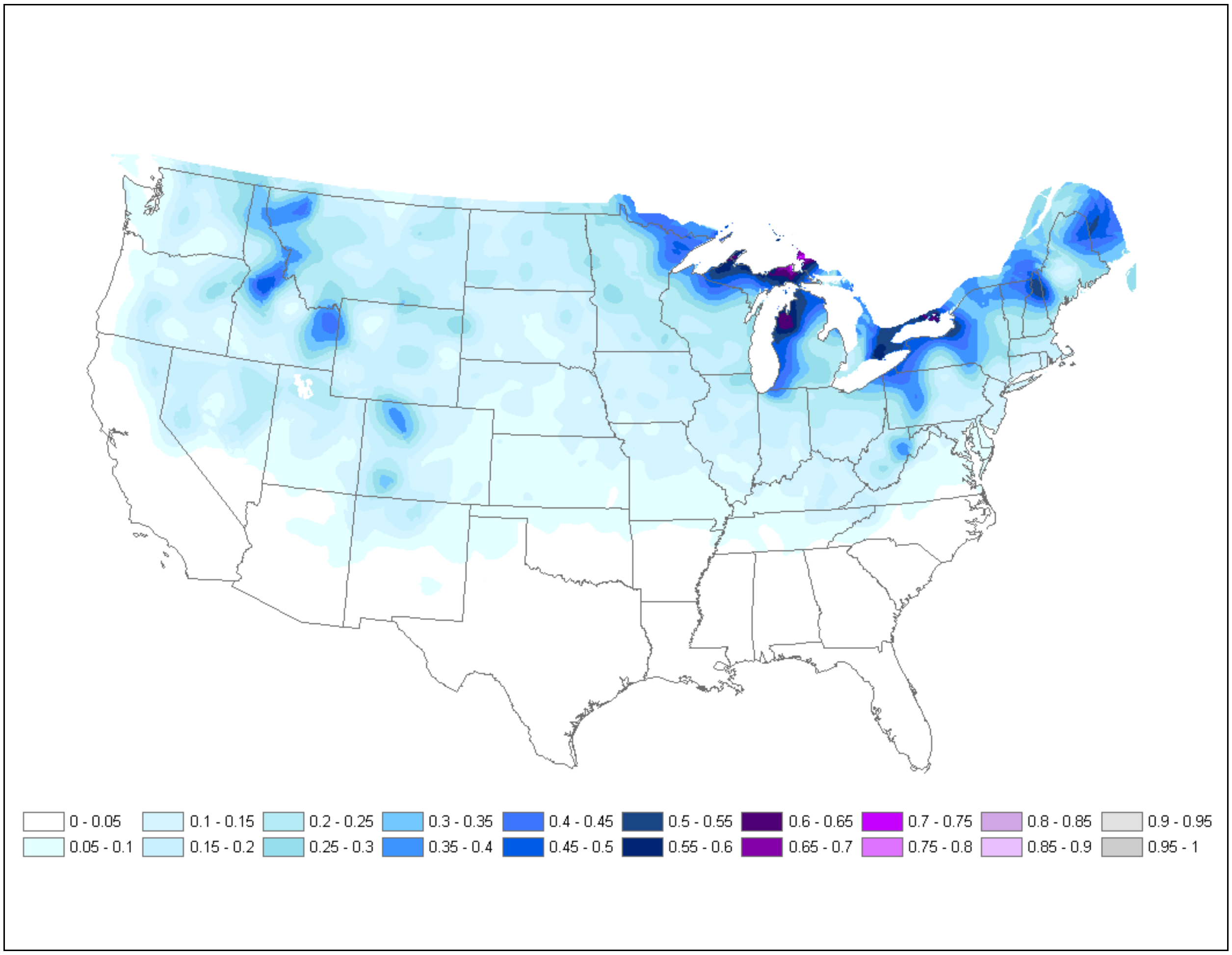

Figure 4. As in Fig. 3, but with no VCE adjustment applied.

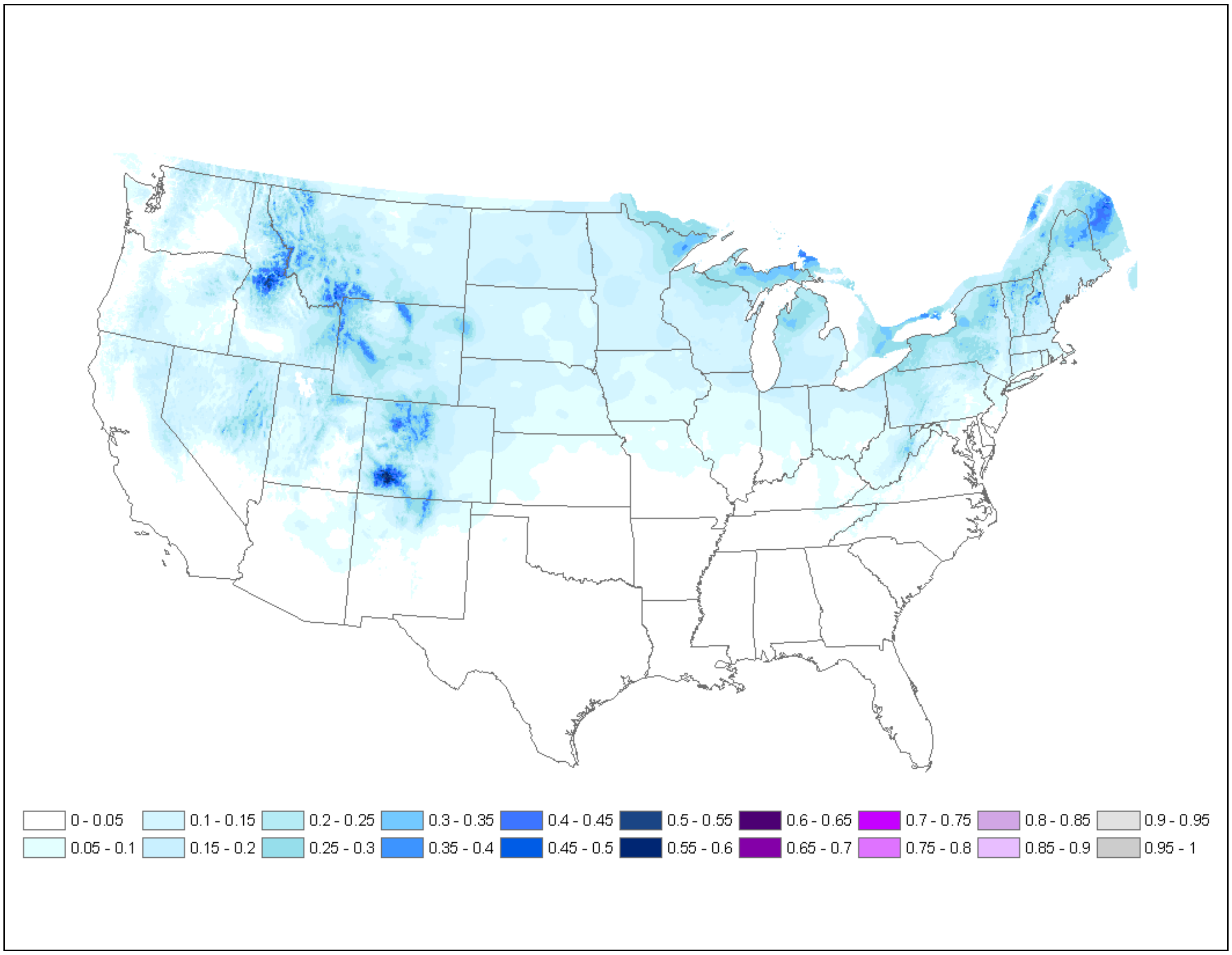

Figure 5. As in Fig. 3, but for March snowfall relative frequency.