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Definition of Dry Thunderstorms for Use in Verifying SPC Fire Weather Products

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Introduction and Motivation

- The National Weather Service (NWS) Storm Prediction Center (SPC) produces outlooks of critical fire weather conditions for dry thunderstorms within the continental United States.
- Dry thunderstorms (dry thunder) occur when minimal to no rainfall reaches the ground in the presence of lightning. The standard definition assumes one or more CG flashes with no more than 0.1 inches of precipitation.
- However, it is not clear that the standard definition represents all or even most cases of lightning caused wildfires. Thus, more precise qualifications are required for forecasters but also for purposes of verification.
- The purpose of this study was to use observational data to better qualify dry thunder events using a variety of classifications methods in the hope of creating a more consistent , realistic, and accurate means of documenting dry thunder occurrence.

Data

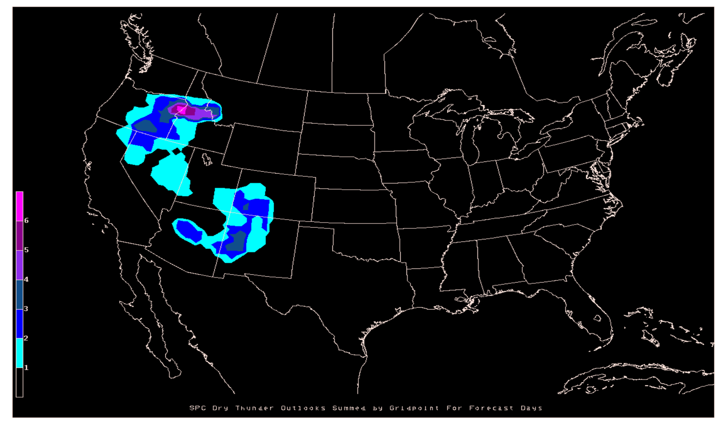
- Period of study: May-Sept. 2013 but results focus on 15 days where Day 1 SPC Dry Thunder Outlook was issued
- Observations constructed for 24-hr period (12-12 UTC) to match Day 1 SPC Dry Thunder Outlooks
- All verifying datasets placed on 40-km (NCEP 212) grid with Day 1 SPC Dry Thunder Outlooks:

1. National Mosaic and Multi-Sensor QPE (NMQ) System (Zhang et al. 2011): Gauge-corrected quantitative precipitation estimates (QPE)
2. National Lightning Detection Network (NLDN): Cloud-to-ground (CG) lightning flashes (LTNG)
3. SPC Mesoscale Analysis (Bothwell et al. 2002): Daily averaged precipitable water (PWAT) and daily minimum relative humidity (RELH)

Dry Thunder Event Classification

- Table below lists methods designed to vary definition of dry thunder. Method 1 serves as control method and represents standard definition. The last 4 methods incorporate environmental parameter thresholds while keeping standard definition for QPE and LTNG.

Method	LTNG (flashes per 24 hours)	QPE (inches)	MINRELH (%)	AVGINPW (inches)
	(>= amount)	(<= amount)	(<= amount)	(<= amount)
1 (control)	1	0.1	NA	NA
2	3	0.1	NA	NA
3	10	0.1	NA	NA
4	1	0.25	NA	NA
5	3	0.25	NA	NA
6	10	0.25	NA	NA
7	1	0.1	30	0.75
8	1	0.1	15	0.75
9	1	0.1	30	1
10	1	0.1	15	1



Grid point count of Day 1 SPC Dry Thunder Outlook Days

Evaluation Techniques: Grid-Point and Neighborhood Approaches

- All datasets placed on 40-km GEMPAK grid (NCEP 212). Dry thunder event grids defined for forecasts and observations in order to perform the objective evaluation. Separate binary (yes/no) grids created for each of the 10 verification methods.

1. **Grid-Point Events:** 2x2 contingency table constructed for all methods by comparing forecast and observed events at each grid-point.
2. **Neighborhood Events**

➢ Outlook areas actually correspond to a *40% or greater coverage* of dry thunder.

- **Neighborhood Events -** Neighborhood fractional coverage computed for observed Grid-Point events by applying radius of influence (ROI) of 120-km. New binary grids for each method created by specifying 40% threshold. Statistics determined once again using 2x2 contingency table.

Verification Methods

Standard forecast verification metrics computed from hits (a), false alarms (b), misses (c), and correct nulls (d):

- **Critical Success Index (CSI) [a/a+b+c], False Alarm Rate (FAR) [b/a+b], Probability of Detection (POD) [a/a+c],**
- **Bias [a+b/a+c], Frequency of Hits (FOH) [1-FAR]**

1) Performance Diagram (Roebber 2009): Bulk, accumulated statistics computed over entire grid from 15-day sample.
2) Spatial Aggregate Plots: GEMPAK Plots of aggregate statistics at each grid point from 15-day sample.

References:

- Bothwell, P. D., J. A. Hart, and R. L. Thompson, 2002: An integrated three-dimensional objective analysis scheme in use at the Storm Prediction Center. Preprints, 21st Conf. on Severe Local Storms, Amer. Meteor. Soc., San Antonio, TX, J117-120.
- Roebber, P. J., 2009: Visualizing multiple measures of forecast quality. Wea. Forecasting, 24, 601–608.
- Zhang, Jian, and Coauthors, 2011: National Mosaic and Multi-Sensor QPE (NMQ) System: Description, Results, and Future Plans. *Bull. Amer. Meteor. Soc.*, **92**, 1321–1338.

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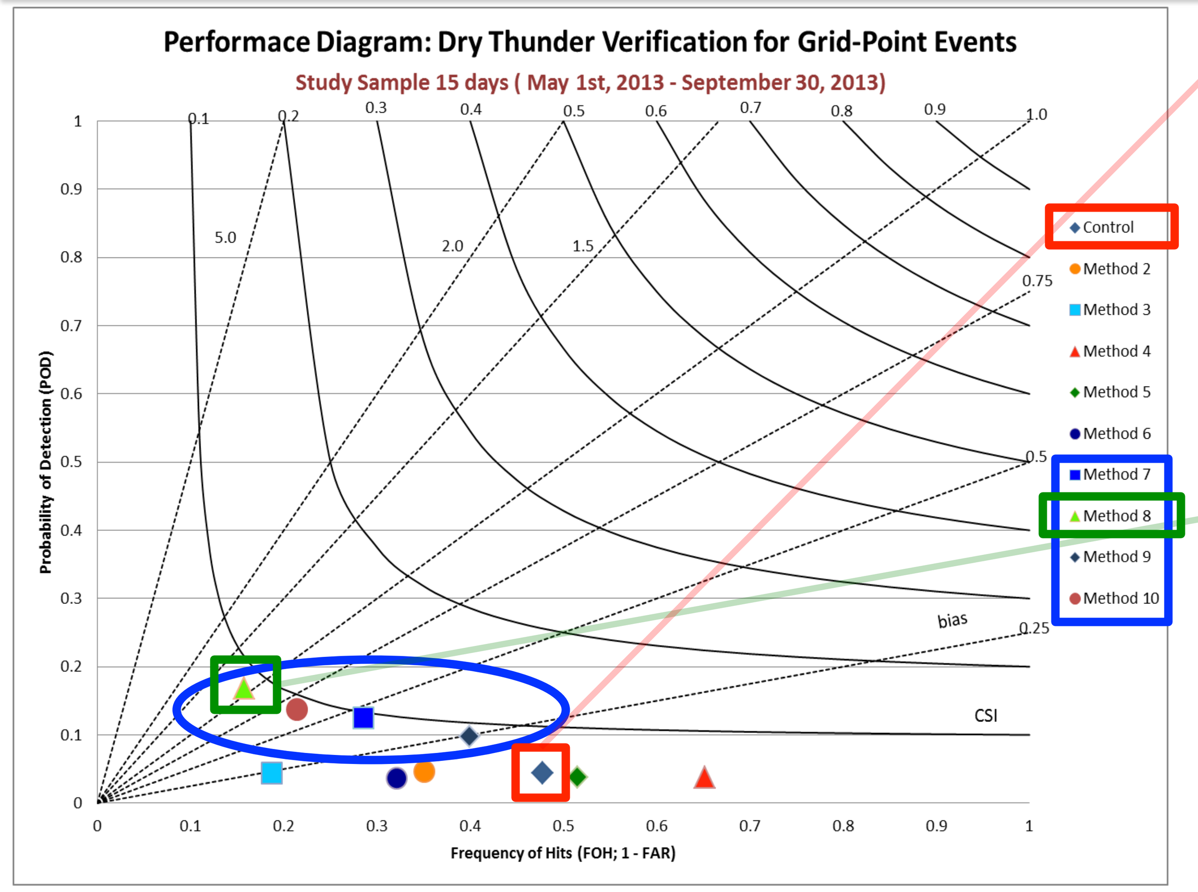
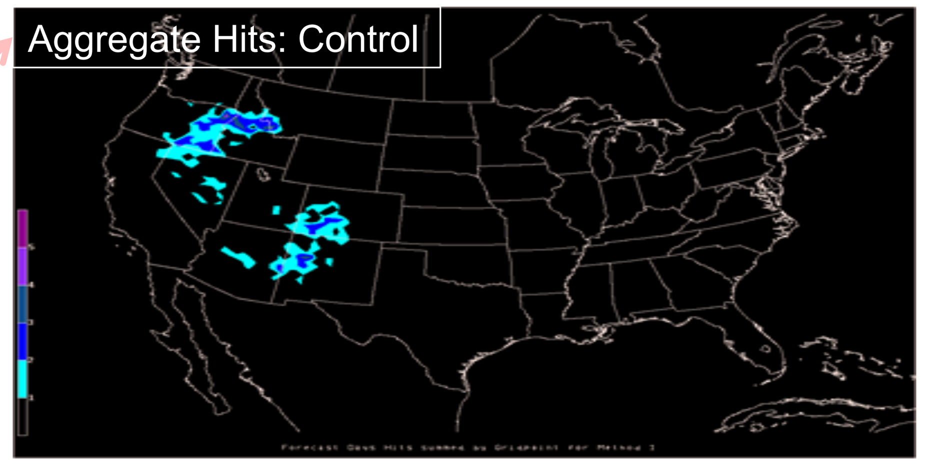
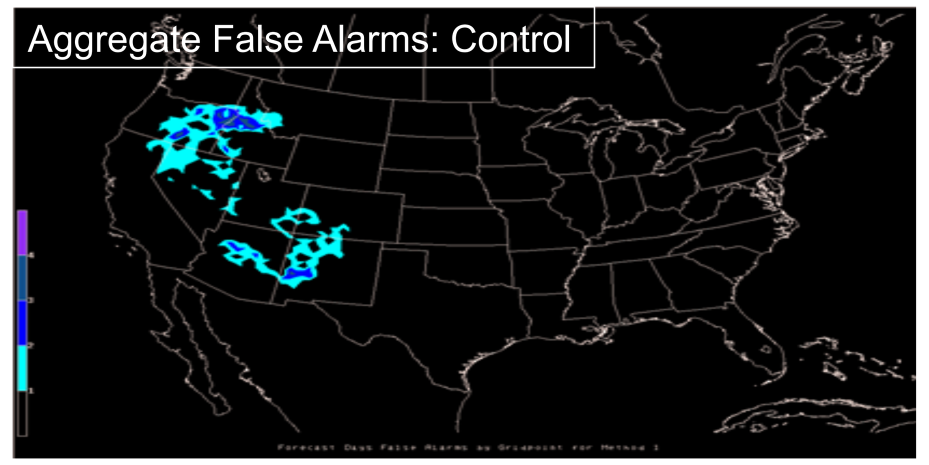
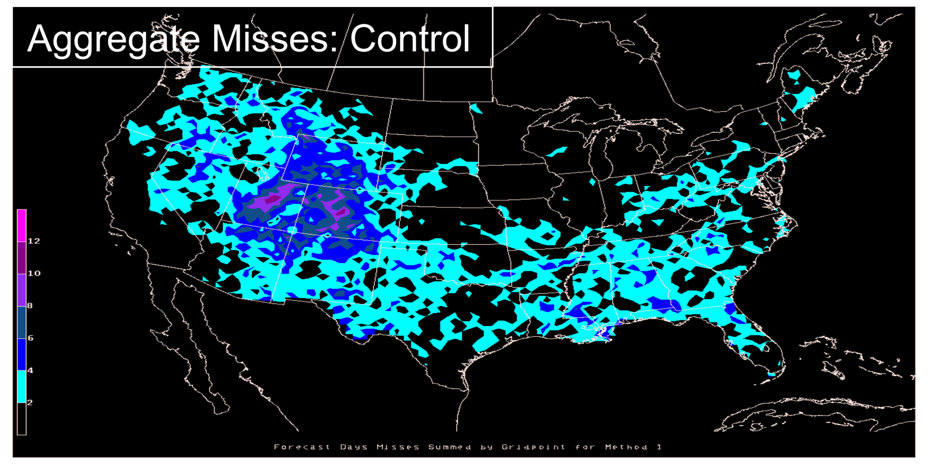
Dry Thunder Verification: Grid-Point Events

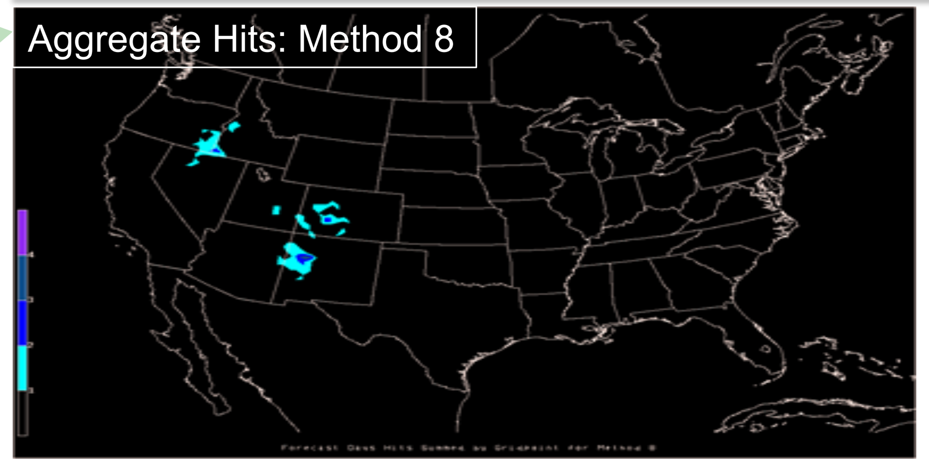


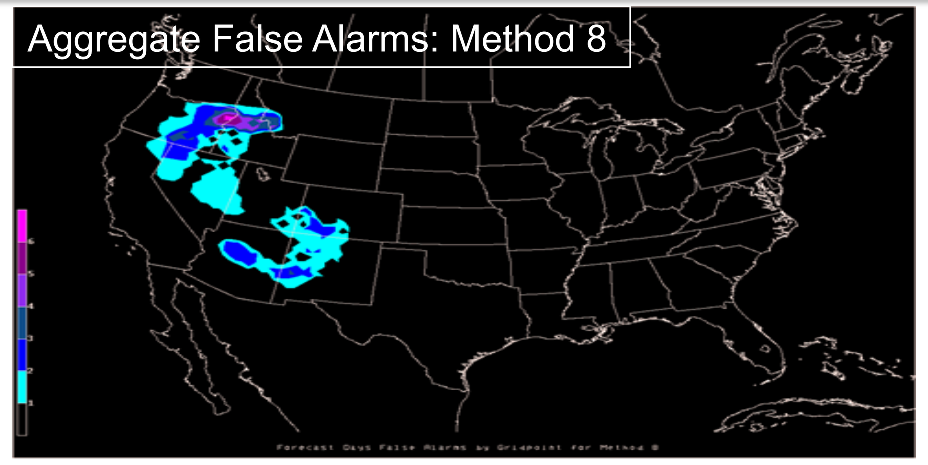
→ Methods 7-10 were favorable over control. All 4 provided similar skill scores but method 8 was chosen as the "best" method due to its reduction of misses.

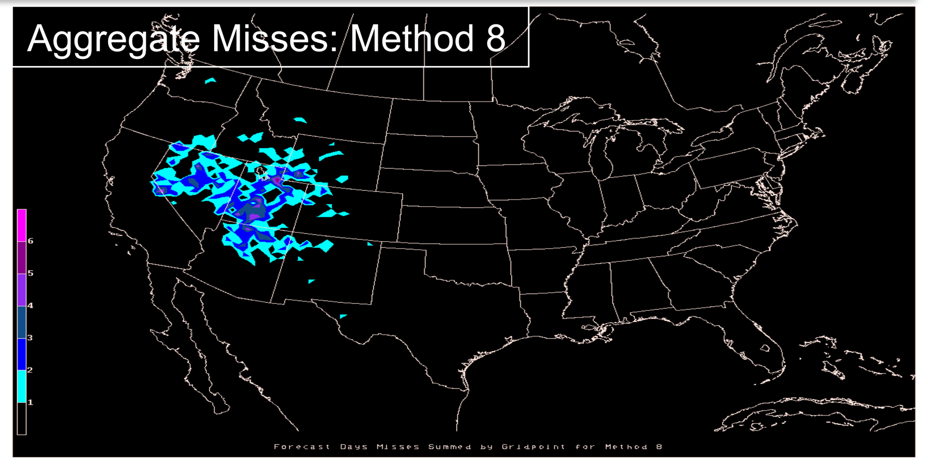










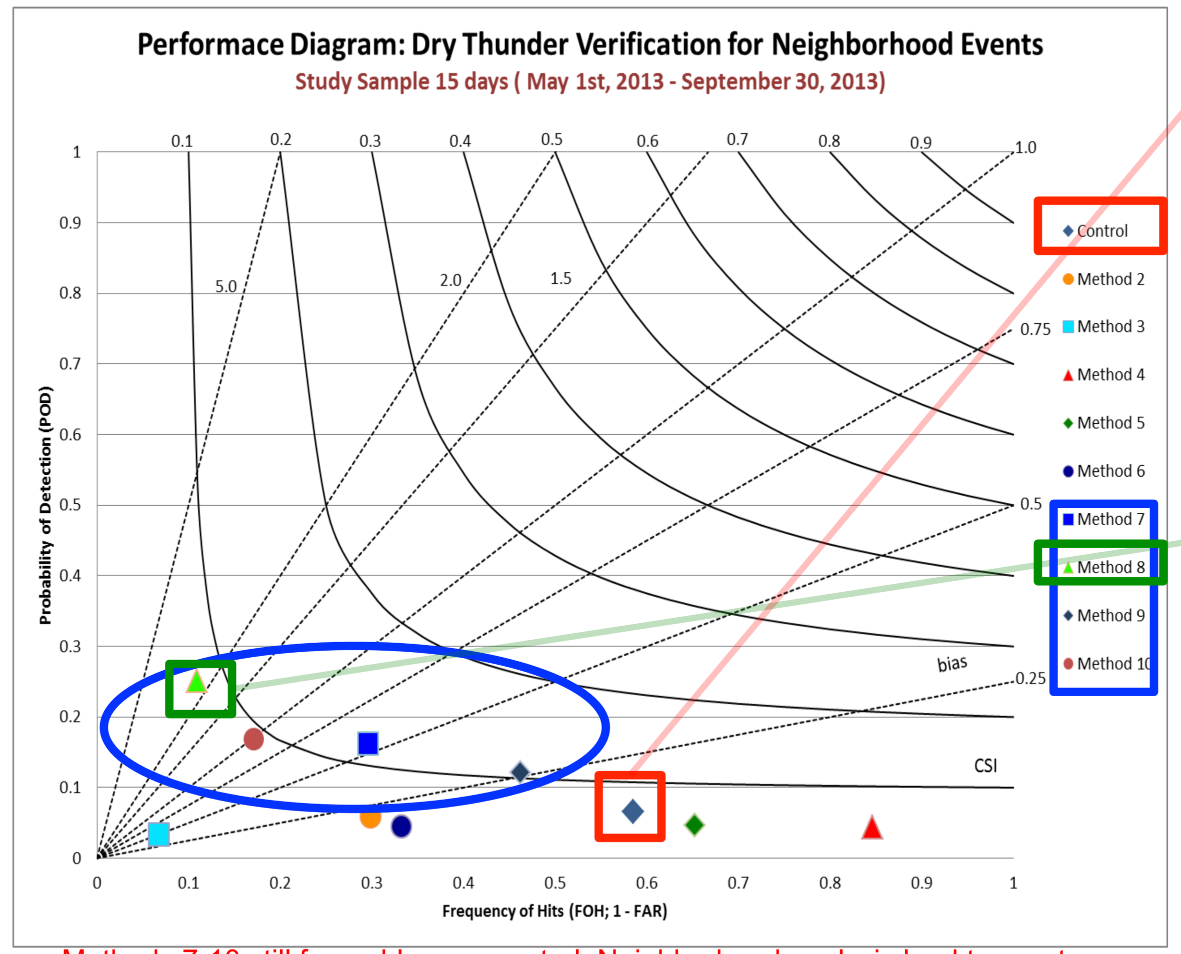


→ Method 8 produced fewer hits than control.

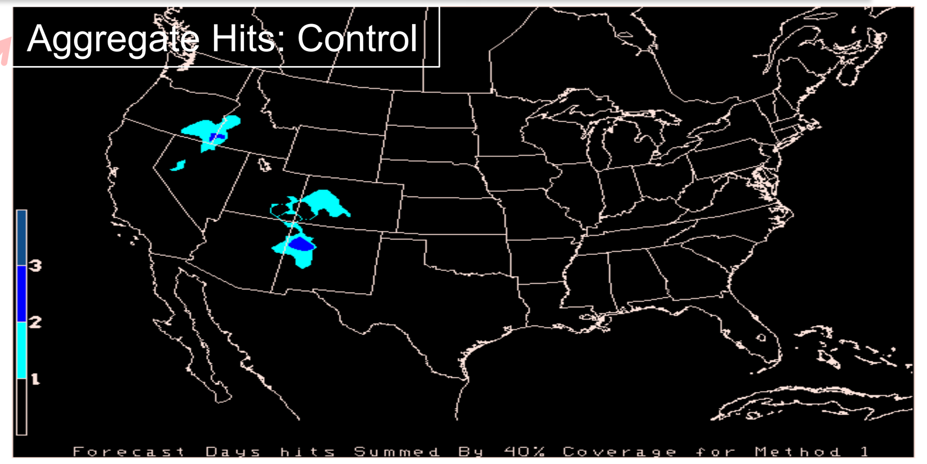
→ Large increase in false alarms for method 8 over control.

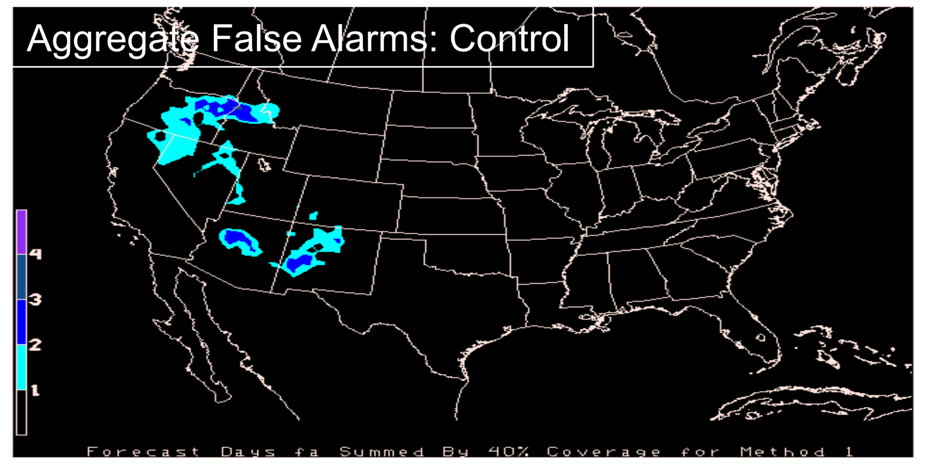
→ Large decrease in number of misses over control, much more restrictive.

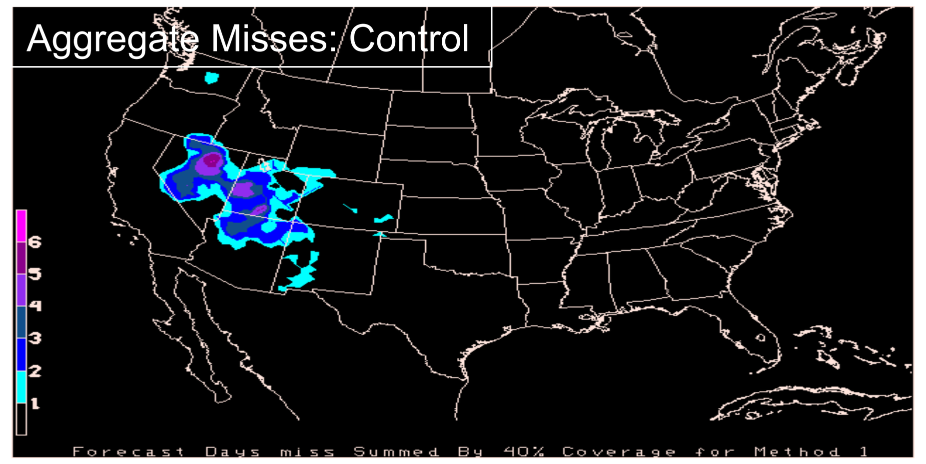
Dry Thunder Verification: Neighborhood Events (>=40% Coverage)

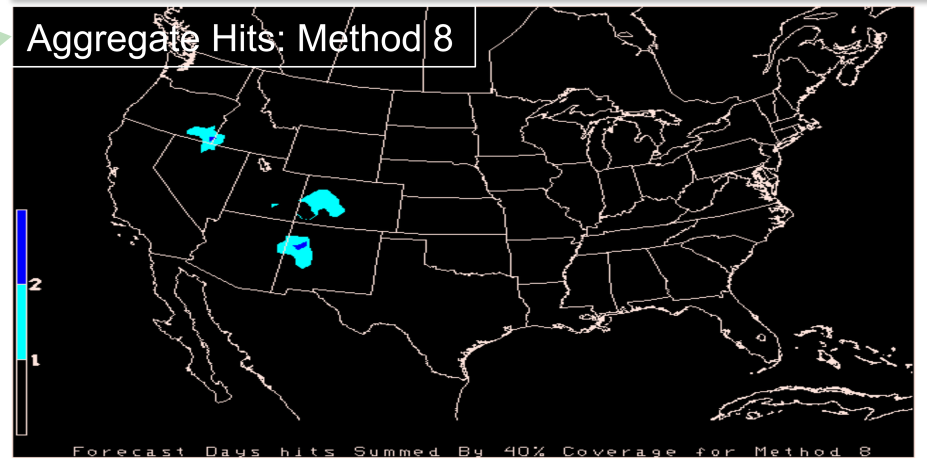


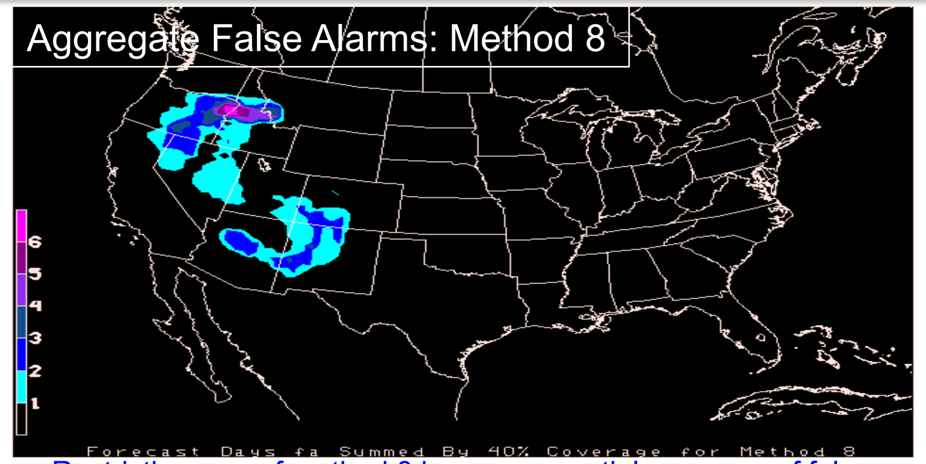
→ Methods 7-10 still favorable over control. Neighborhood analysis lead to greater range of skill scores compared to the Grid-Point event analysis.

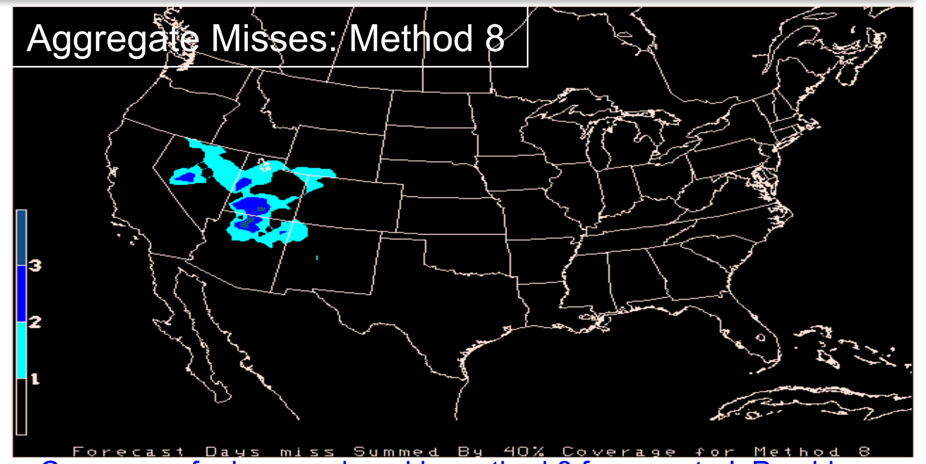












→ Control and method 8 provided similar spatial coverage of hits.

→ Restrictiveness of method 8 increases spatial coverage of false alarms over control. Although, the spatial pattern is similar.

→ Coverage of misses reduced in method 8 from control. Provides evidence on higher skill scores for method 8.

Summary and Conclusions

- Utilizing observational datasets, the current work explores ten methods of classifying dry thunder events by comparing against Day 1 SPC Outlooks issued from May-September 2013. In addition to combining variable thresholds for radar-derived QPE and NLDN CG flashes, the effect of including environmental parameters was also considered in several methods. The spatial extent of the events was also examined by determining the fractional coverage of dry thunder in the ROI.
- The standard definition [one or more CG flashes with no more than 0.1" of precipitation] for dry thunder resulted in many more observed than forecast events with a high FOH, but low POD. Misses from the control method were spread over a large portion of the country. The low frequency and isolated nature of the observed events was eliminated from the southern and eastern United States by requiring 40% coverage to dry thunder.
- By incorporating low RELH and PWAT into standard thresholds for dry thunder, the number of events identified are reduced, resulting in improved skill scores compared to the control method. Method 8 was chosen as best, owing to its reduction in misses.
- For the short time period investigated, the addition of environmental parameters and a spatial-coverage criterion into the dry thunder definition reduced the number of observed events to better agree with the forecasts. Future work should expand to include Day 1 SPC Outlooks from more years and possibly more thresholds. Other environmental parameters could also be taken into account, including fuel dryness.