Verification of In-flight Icing and Turbulence Algorithms: A Gridded Approach

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1. Introduction

With the development of many products over recent years to diagnose and forecast in-flight icing and turbulence, a need for an improved verification technique has become apparent. The most common method used for verification of these algorithms and forecasts is a point-to-point technique, in which individual pilot reports (PIREPs) are compared to the forecasts/diagnoses at nearby grid points. This method has been criticized due to the non-systematic reporting by the PIREPs, in both location and time, and the inherent strong bias toward reporting a large number of unrepresentatively large number of positive events.

It has been suggested that a gridded verification technique with the use of PIREPs as observations for this grid might be a useful way to avoid the problems that are evident with the point-to-point method. The use of a grid over a specific amount of time would theoretically correct for the spatial and temporal problems that have existed in previous studies. Also investigated in this study was the calculation of the number of the PIREPs that have matching locations in time and space in order to assess the possibility of eliminating these "extra" observations and correct for biases over high traffic areas

2. The Analysis

The Grid

- 40km grid was assumed and +/- 1000 ft in the vertical over the CONUS

The Data

- Positive and negative PIREPs over the CONUS for February 2000
- In addition, "turbulence with no icing report" and "neither turbulence nor icing" were used as indicators of "no icing"
- ARTCC departures were also considered for parts of this analysis

The Analysis

- PIREPs and "departures" were calculated for February 2000 and averaged over six hours
- Number of reports was compared to number of grid points over the CONUS and each ARTCC region
- Analysis was based on a 12 hour flight day because of the lack of flights during the night

The Second Analysis

- Data was filtered for PIREPs that had at least one match over a grid point
- Resolution was 40km and +/- 100ft in the vertical

3. Best-case scenario

- The data analyzed was the total number of departures from each ARTCC region for the month of February 2000.
- Computed average grid coverage if reports were received by all departing ARTCC flights.
- Data was assumed to be uniformly distributed over the grid
- Table 1 shows the number of departures over the CONUS for the month and the average percentage of the grid that could have been covered over a six hour period

Table 1

Number of Departures (FEB 2000)	Coverage over six hour period
893,148	12.55%

4. Semi-possible Scenario

- The data analyzed was the valid PIREPs over the CONUS for the month of February 2000.
- Computed average coverage of the 40km grid would be covered over a certain amount of time
- Uniformity was also generously assumed over the grid
- Table 2 shows the number of PIREPs and the average percntage of coverage over a six hour period

Table 2

Number of PIREPs (FEB 2000)	Coverage over six hour period
35,293	0.50%

5. A possible alternative

- Limit analysis to smaller domains over specific ARTCC regions
- Assess the possibility of adequate grid coverage over areas with more flight traffic
- Spatial resolution of the grid is the same as in previous analyses (40km)
- PIREPs were grouped into their specific ARTCC region
- Figure 1 and Table 3 show/list individual ARTCC regions with the average six hour coverage over each region

Figure 1. A map of average coverage in each ARTCC region for the month of February 2000

6. Matching PIREPs

- **GOAL**: Investigate the possibility of eliminating known biases over high traffic areas
- Organized PIREPs by specific grid point
- Eliminated PIREPs that did not match at least one other report in both location and time
- The criteria for a matching PIREP to be within 40km horizontally and 1,000 ft vertically over an hour time period
- Analyzed the results to investigate whether there was an adequate number of reports that fit the given criteria to warrant further analyses
- Table 4 shows the number total number of PIREPs that have at least one match and the average percentage of the entire amount of PIREPs from February 2000
- Table 5 shows the type of matches and the average percentage of entire set of matched PIREPs

Table 4

PIREPs with at least one match	Percentage of all valid PIREPs
1,255	3.46%

Table 5

Type of matched PIREPs	Percentage of matched PIREPs set
2 matching reports	94.03%
3 matching reports	3.92%
4 matching reports	1.64%
5 matching reports	0.41%

Figure 2. A map of FEB 2000 PIREPs

7. Conclusion

The use of a gridded approach to verification would be a useful way to alleviate biases, and both temporal and spatial errors experienced with the point-to-point verification approach that is commonly used. The problem with this alternative method is the lack of enough data to satisfy a grid with 40km resolution. The numbers of PIREPs are not adequate for a grid of this magnitude. Even if a sufficient amount of observations were available, Figure 2 demonstrates the lack of spatial uniformity in these reports. Limiting the grid to smaller ARTCC regions with relatively high traffic also resulted in an insufficient number of reports and inadequate potential coverage of the grid. Without another type of observation, as opposed to PIREPs, a gridded approach is not feasible for verification of either in-flight icing or turbulence products.

The calculation of the number of PIREPs that matched in both location and time also shows a relatively small number of situations when this overlap of observations was evident. In the instances where there were matches, the calculations showed a very large number (>94%) had only one match. While there are known biases around areas of high traffic, the percentage of observations that cover the matching criteria is minimal (3.46% of all valid PIREPs). Thus, the effect this change in technique might have on the overall scoring of these algorithms would also be minimal.

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