Analysis of Two Turbulence Forecast Indices Using Pattern Recognition And Eddy Dissipation Rate

Richard DiMaio
Department of Geography
Northern Illinois University

ABSTRACT

The purpose of this study is to assist and improve the verification process of the Graphical Turbulence Guidance (GTG) product currently in use by the Aviation Weather Center (AWC). One of the components of the GTG algorithm involves the incorporation of the Eddy Dissipation Rate (EDR). EDR is an in situ measurement in units of turbulent kinetic energy and is based on a transformation of the observed vertical acceleration to obtain a measurement of atmospheric turbulence that is independent of aircraft characteristics and motions.

An improved method to utilize Eddy Dissipation Rate (EDR) is described. A qualitative analysis involving five distinct synoptic-scale upper level wind patterns was conducted from 29 significant turbulence events over a four-month study period. It is the goal of this research to determine if any synoptic-scale patterns are better predicted than others using this approach correlating predicted Ellrod and Ellrod-Knox indices used by the Graphical Turbulence Guidance (GTG) with EDR data. Since real-time EDR data are not available to operational forecasters at the AWC, it is hopeful that this study will assist in real time evaluation of the intensity and duration of ongoing and predicted turbulence events and further improvements in forecast algorithms.

Synoptic Pattern	Date		Turbulence Reports	
			TI	DTI
Short-Wave	7,26,29,30 14,18,23 7,14,24,26,28 11,14	December January February March	138	138
Long-Wave	11,12,26,30,31 2,7 9,10,14,30,31	December February March	149	155
Downslope	11 18	December January	16	18
Anti-Cyclonic	28 16 5	December January February	33	33
Merging Jetstreams	6,7	January	35	35

Brief Data Analysis

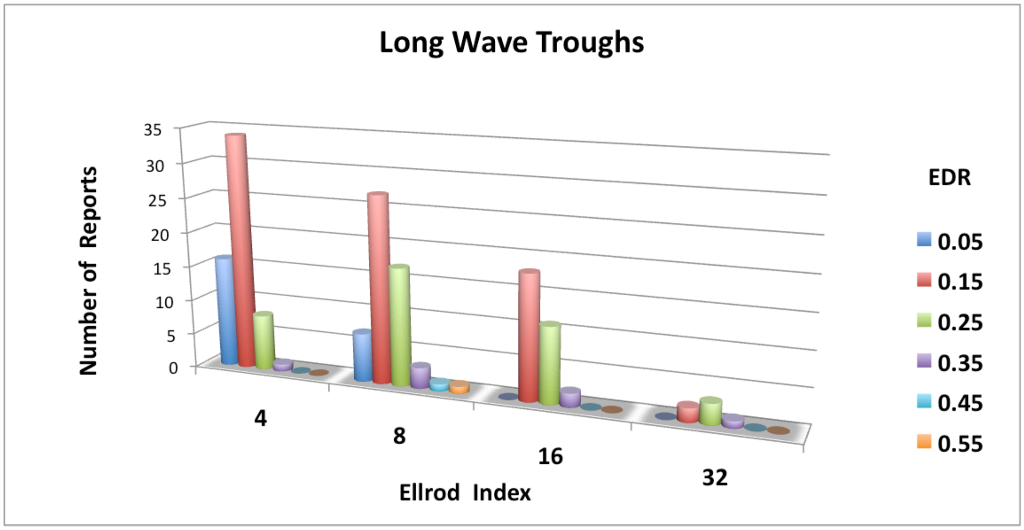
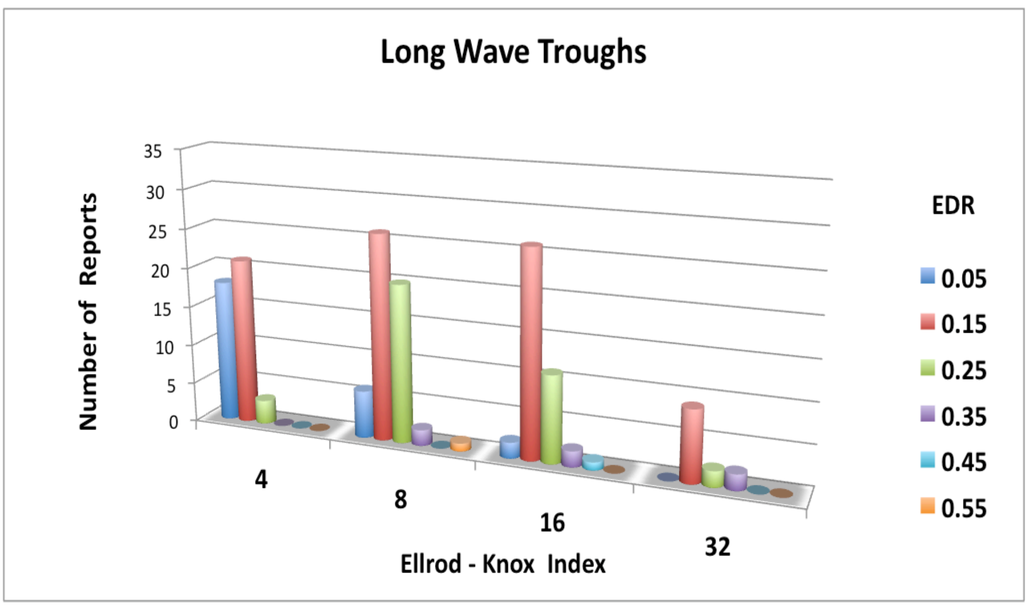


Table 2. Relationship of TI, DTI and EDR with occurrence of moderate turbulence within five distinct synoptic-scale flow patterns.



FINAL ANALYSIS

Synoptic Pattern	Index	Value	EDR
Short - Wave	TI	8 - 16	.15 to .25
	DTI	8 - 16	.15 to .25
Long - Wave	TI	4 - 8	.15
	DTI	4 - 16	.15
Down-slope	TI	8 - 16	.25
	DTI	8 - 16	.25
Anti-Cyclonic	TI	4 - 16	.25
	DTI	4 - 16	.25
Merging Jetstreams	TI	4 - 8	.05
	DTI	4 - 8	.05

F. Appendix: Forecast Example

After recognizing the synoptic-scale pattern that exists, a forecaster can then evaluate the TI and DTI output at different levels from either the RUC or NAM (North American Mesoscale Model) available on the AWC Aviation Testbed Experimental Display page, (http://aviationweather.gov/exp/ellrod/ruc/), and cross-reference both PIREPS and (when available) EDR data. Figure 51 is an example of an anti-cyclonically curving jetstream from Idaho into central California. Figure 52 shows the Ellrod Index or TI clearly indicating a potential for turbulence for the time period, 12 January, 2012, 18 UTC from 34,000 to 39,000 feet. Note the large area of predicted values from 4 to 16 over central California into central Montana.

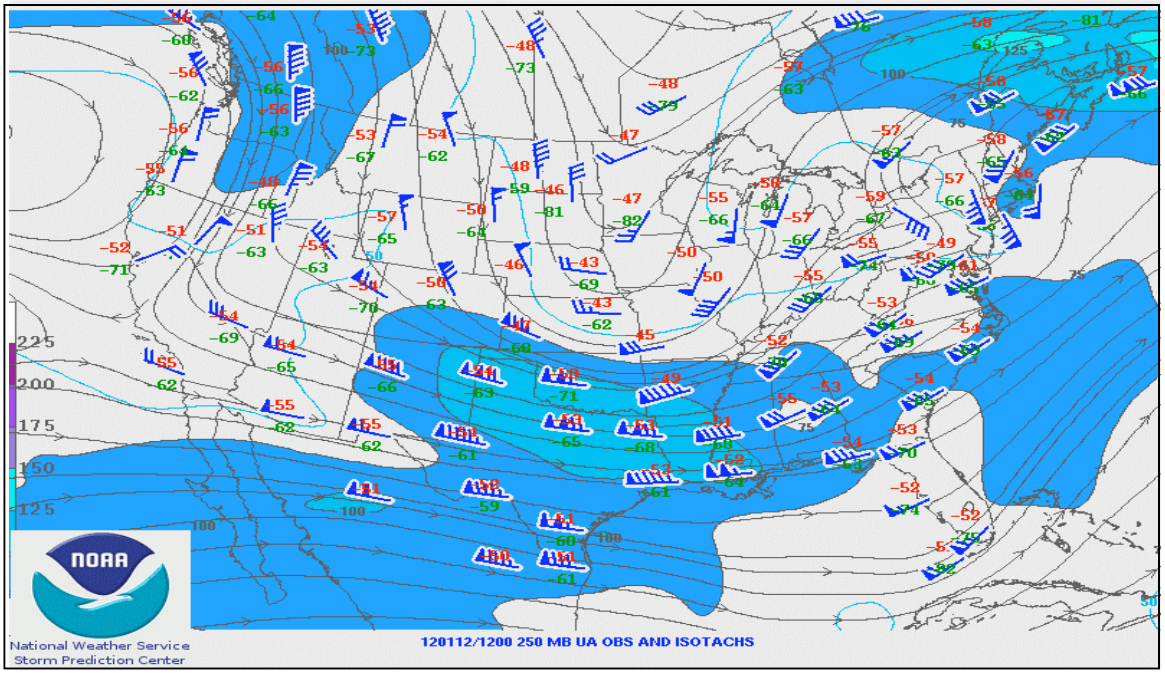


Figure 51. 250 hPa analysis at 1200 UTC, 12 January 2012

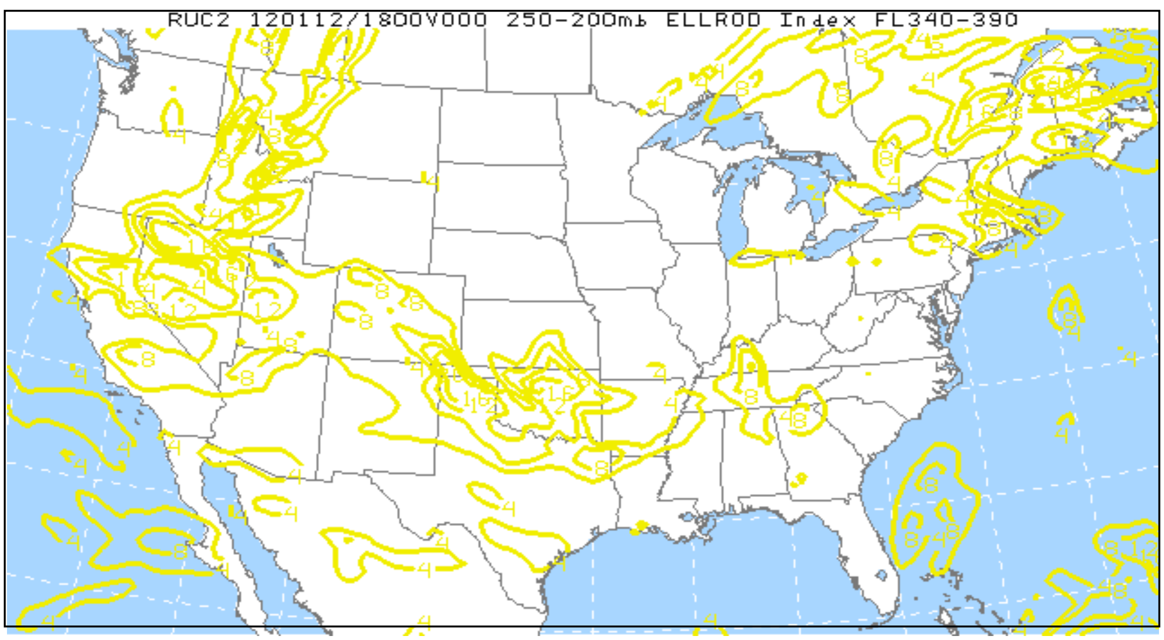


Figure 52. Ellrod Index (TI) Forecast for 12 January 2012, 18 UTC,

Figure 53 shows the GTG2 correctly predicting an area of potential turbulence from Idaho into central California with darker shades indicating the potential for moderate or greater turbulence. Figure 54 shows seven PIREPS indicating moderate turbulence from FL 33,000 to FL 40,000, between 1719 UTC to 1843 UTC, within the area highlighted for potential turbulence by TI and GTG2.

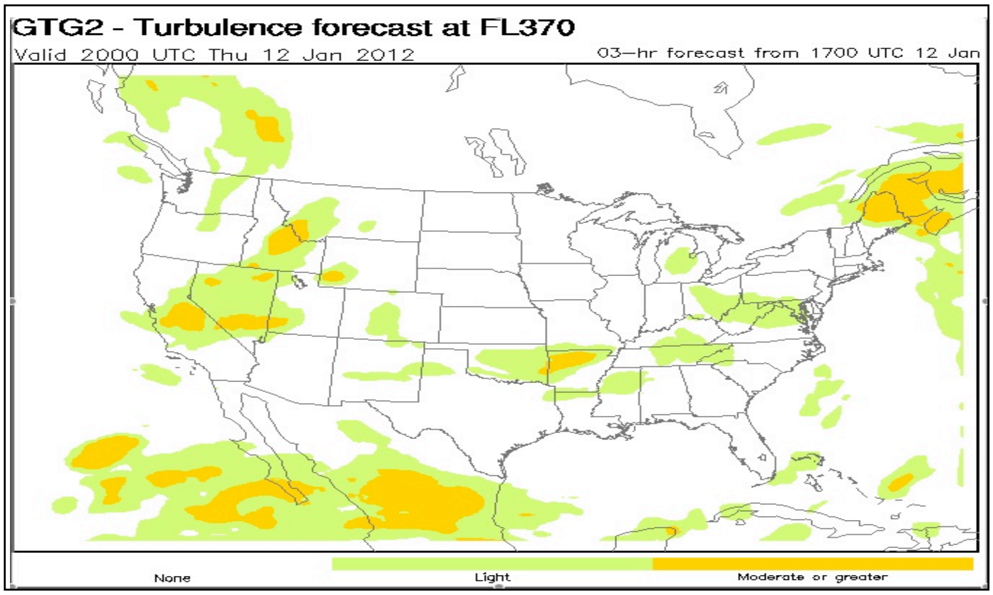


Figure 53. Moderate or greater turbulence is predicted over a small portion of the western US at FL 37,000 feet for 20 UTC, 12 January, 2012.

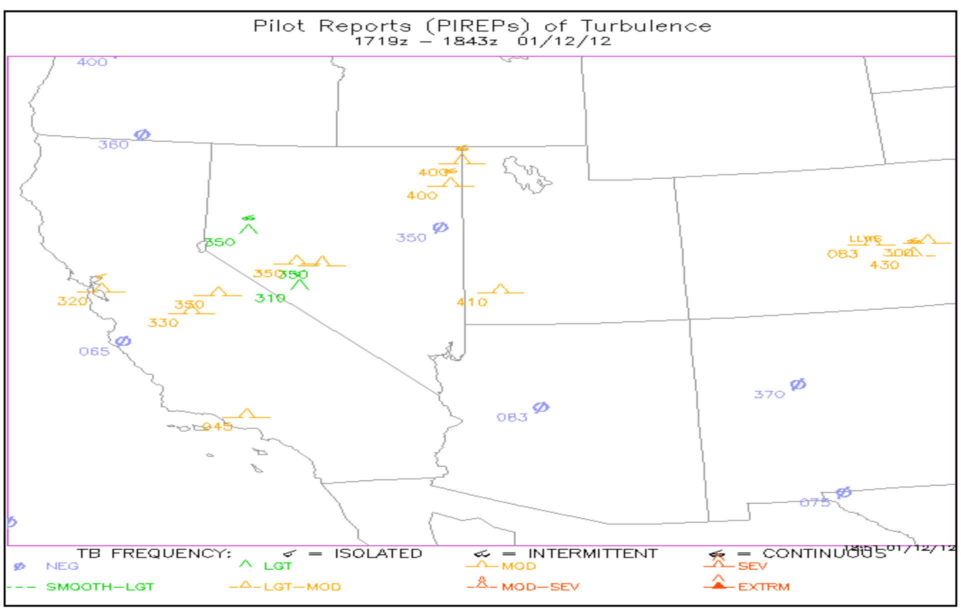


Figure 54. PIREPS of turbulence for 12 January, 2012, 1719 UTC to 1843 UTC. Report is in thousands of feet. Intensity of turbulence is described in legend.

Figure 55 shows four AIRMETs issued by the AWC at 1445 UTC, 12 January, 2012 for the potential for moderate turbulence. Note the two AIRMETs covering a large area of the western US for the possibility of moderate turbulence between FL 18,000 feet and FL 41,000 feet over California and Nevada and a second for FL 27,000 feet to FL 39,000 feet over the northern Rockies.   As mentioned earlier, AIRMETs cover a much larger area, less severe weather, such as moderate turbulence, and are valid for three to six hours. A SIGMET will generally be issued for four hours or less and cover such weather phenomena as severe or greater turbulence, icing or instrument meteorological conditions due to dust, sand or volcanic ash for a smaller region. In this event, a SIGMET was not needed since the turbulence was only moderate.

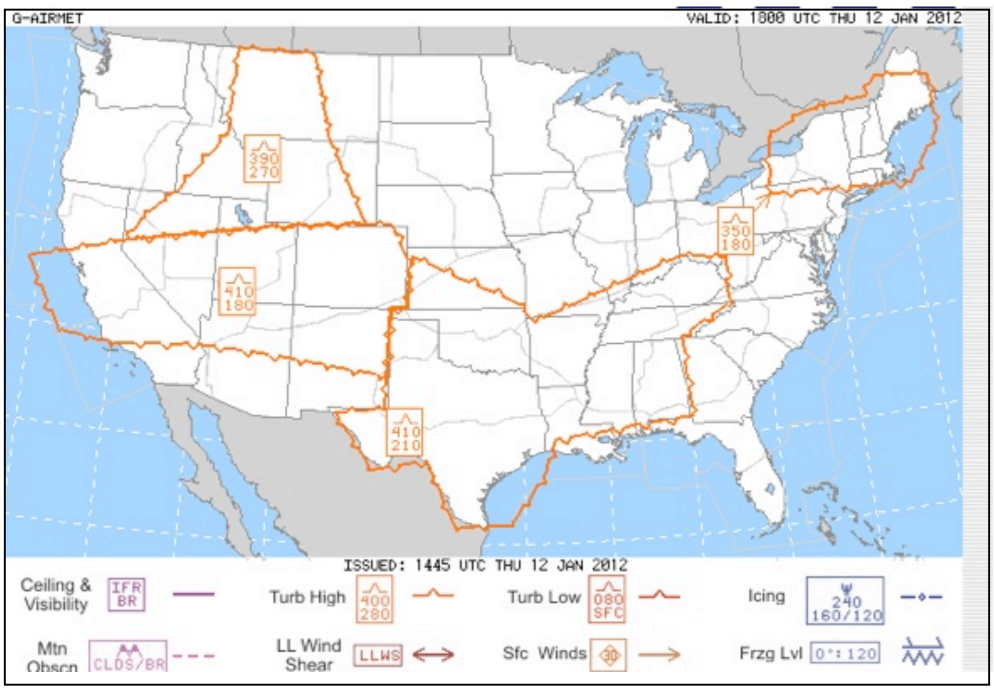


Figure 55. AIRMETs issued at 1445 UTC valid from 18 UTC 12 January 2012 to 00 UTC 13 January, 2012. Large brown polygons are AIRMETS indicating potential intensity of clear air turbulence with corresponding flight levels.

The following maps (Figures 56 – 58) show three separate reports of EDR from .25 to .35 over central California and western Nevada within the vicinity of the seven reports of moderate turbulence. By cross-referencing Figure 50, these values fall in line with values associated with moderate turbulence in anti-cyclonic jetstreams.

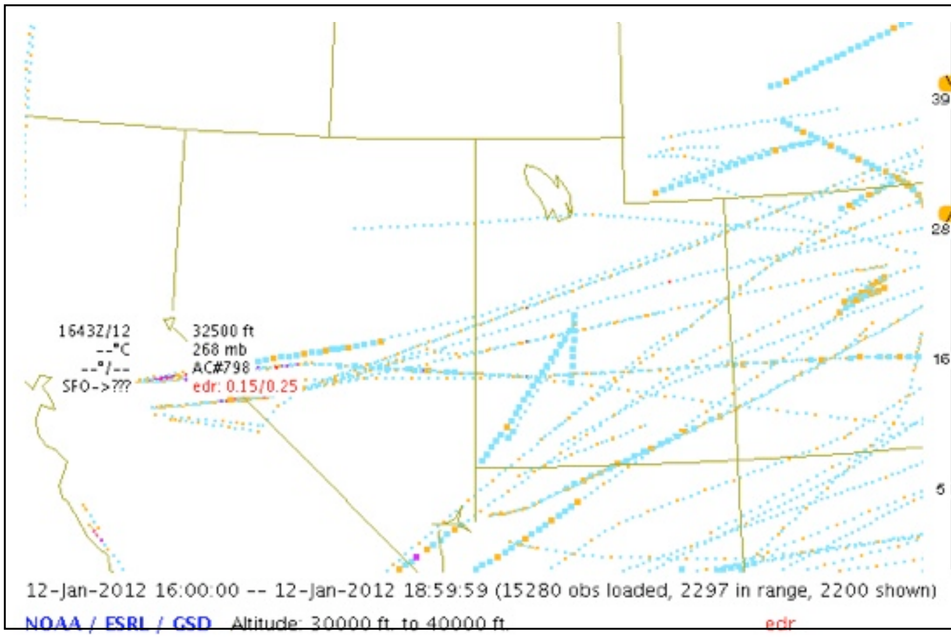


Figure 56. Sub-plot of AMDAR data, displaying peak EDR of 0.25 at 268 hPa or FL 32,500 feet over central California at 1643 UTC.

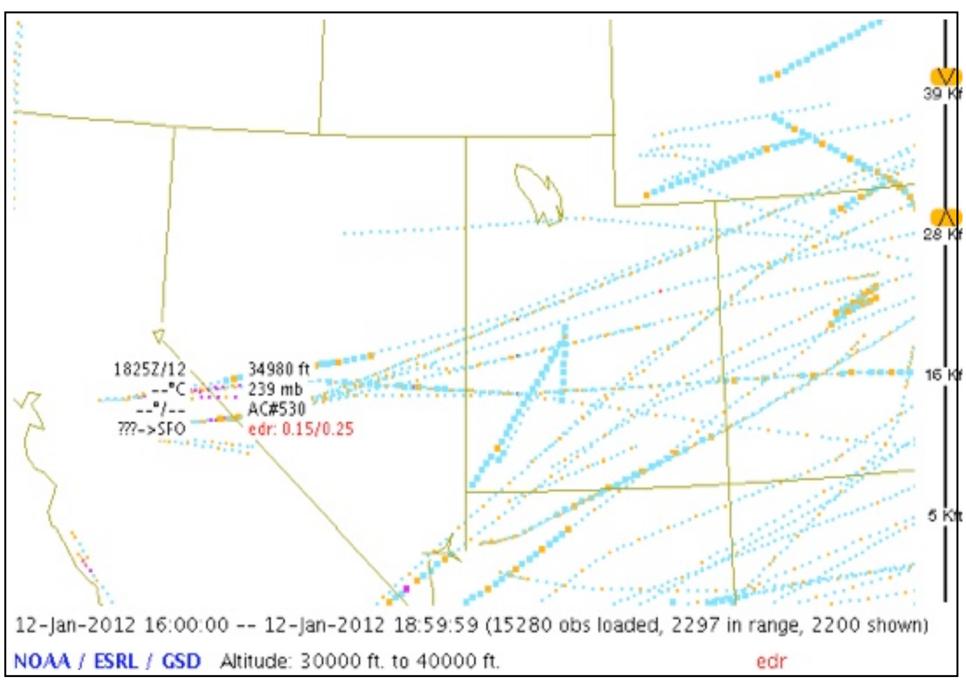


Figure 57. Sub-plot of AMDAR data, displaying peak EDR of 0.25 at 239 hPa or FL 34,980 feet over central California at 1825 UTC.

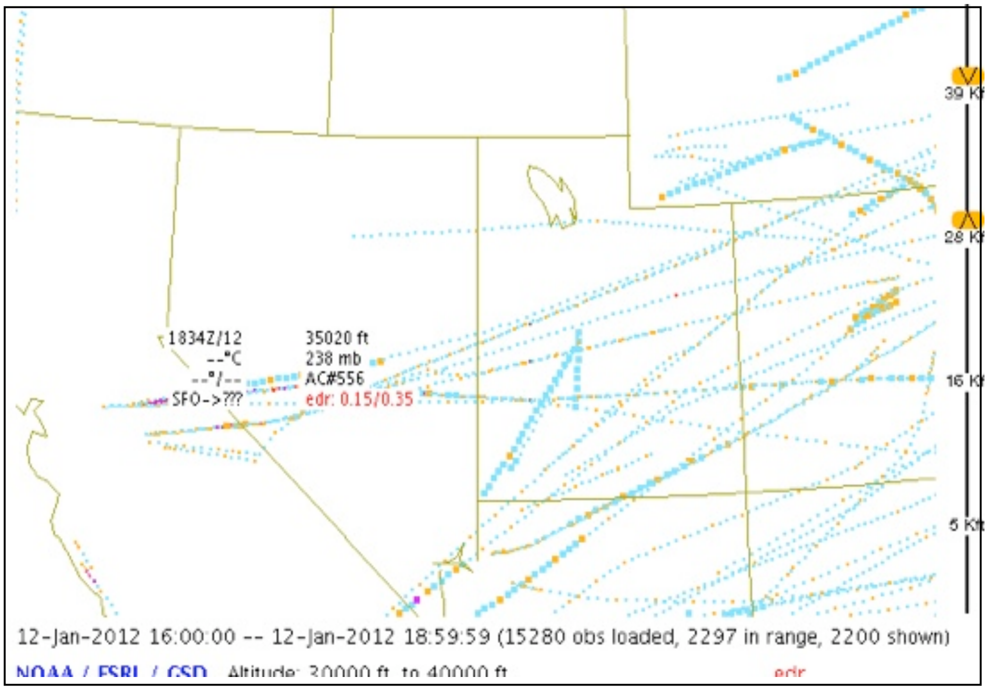


Figure 58. Sub-plot of AMDAR data, displaying peak EDR of 0.35 at 238 hPa or 35,020 feet over western Nevada at 1834 UTC.

Although it is unclear whether or not these EDR reports are the same aircraft associated with the PIREPS, it does demonstrate the value of EDR data in the real-time operational mode to further validate intensity and flight level of turbulence in certain synoptic-scale patterns and assist forecasters in refining turbulence forecast products. Although a SIGMET was never required for this event, additional EDR data and pattern recognition might have provided the forecaster the needed information to either decrease the size of the AIRMET, reduce the range of the altitude of the advised area, or simply have a greater level of confidence in assessing the current state of the atmosphere.