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Date: March 19, 2024

Subject: NTSB Investigation DCA24LA124, N411WN, Boeing B737-7H4, Aylett, Virginia, March 9, 2024 at 1331 eastern standard time. Weather Reports and Records.

On March 19, 2024, the NTSB Operational Factors Division provided the following information via email:

The following turbulence related Pilot Reports were recorded in the vicinity (40-70 nm southwest) of the event, during the 15 minutes preceding the event:

(1) FCI UA /OV FAK245035/TM 1817/FL250/TP PC12/TB SEV
/ / / / /-Turbulence: Severe
/ / / /-Aircraft Type: PC12
/ / /- Flight Level: 250
/ /- Time: 1817Z
/ /- Location – 245° and 35 nm from FAK VOR
/- Nearest weather reporting station: FCI, Type of report: UA=Routine Pilot Report (UUA = Urgent)

(2) FVX UA /OV GVE180060/TM 1821/FL180/TP B739/TB MOD 160-180
(3) EMV UUA /OV LVL010015/TM 1822/FL210/TP A320/TB MOD-SEV CAT
(4) PTB UUA /OV LVL010025/TM 1825/FL240/TP CRJ9/TB MOD-SEV CAT

Accident 1831Z/1331 EST

Figure 1 shows the approximate locations of the pilot reports and N411WA, which is also shown graphically in figure 8.

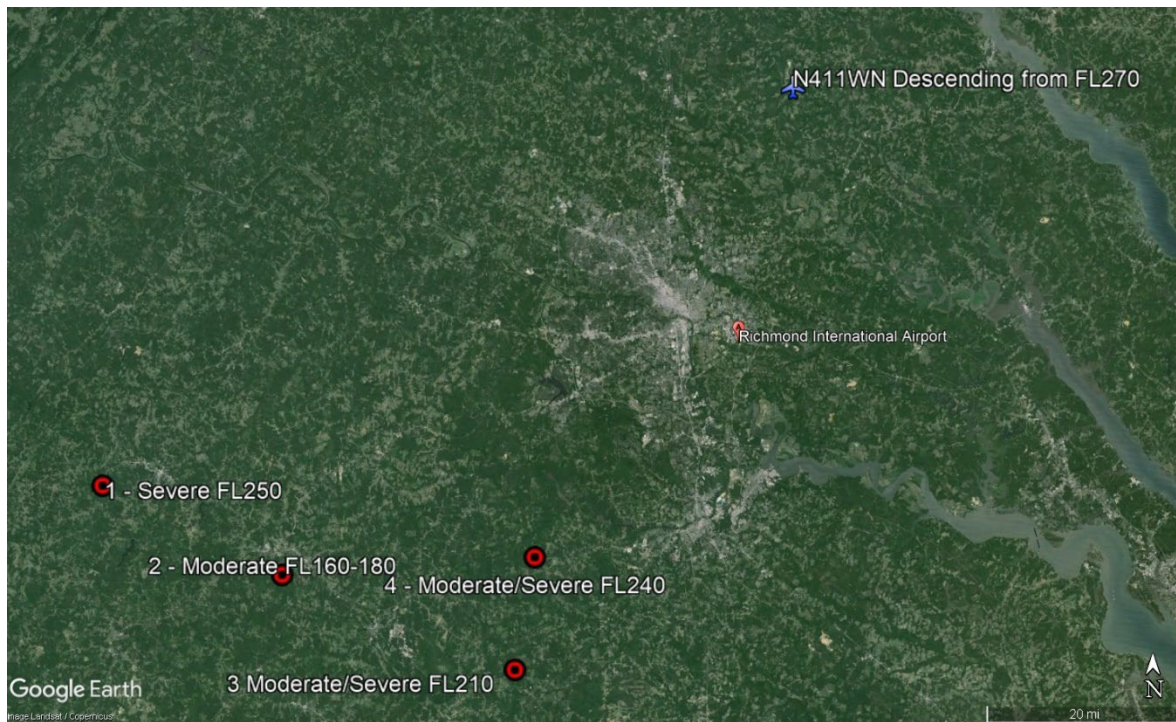


Figure 1 Pilot Report Locations

A depiction of the surface observations from the NWS Aviation Weather Center's webpage for 1330 EST is included as figure 2 with the approximate turbulence location marked by a red star and the frontal systems from the 1300 EST analysis. The turbulence location was in the vicinity of a warm front with numerous stations surrounding the location reporting IFR to MVFR conditions due to low ceilings and visibility in light to moderate rain.

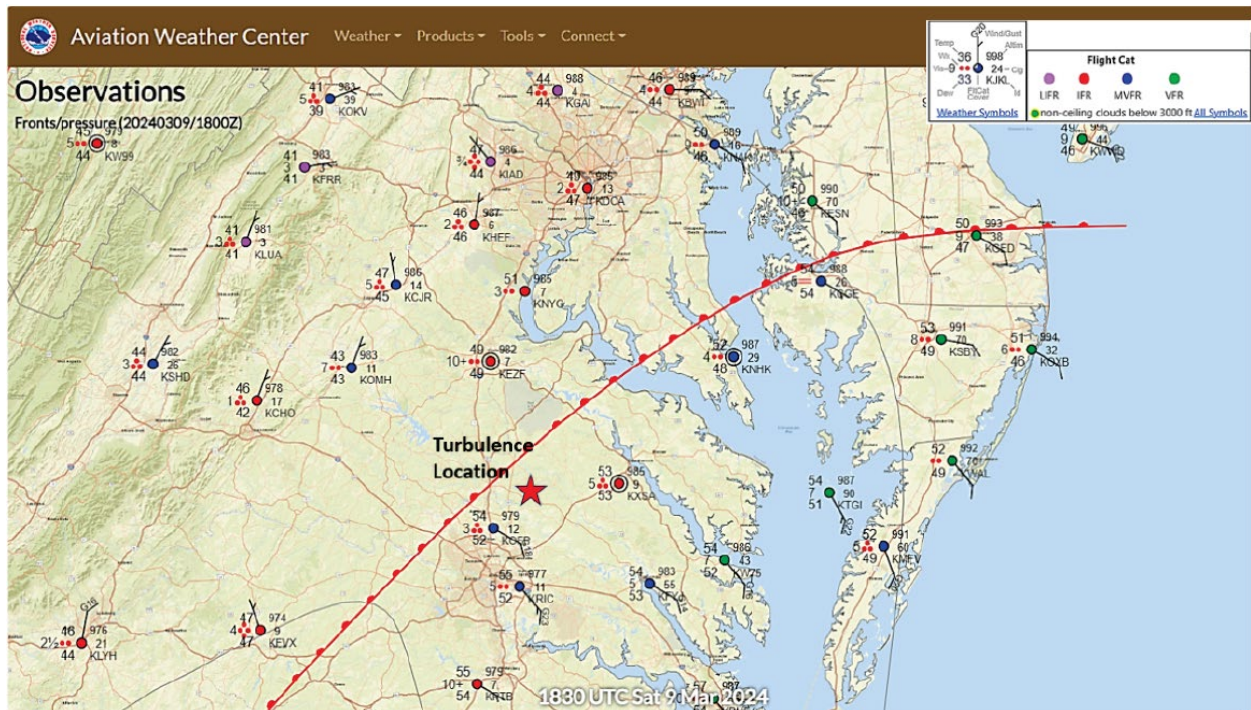


Figure 2 - NWS Aviation Weather Center's METAR display with fronts overlaid for 1330 EST.

Figure 3 is the KAKQ WSR-88D Enhanced Echo Tops (EET) product for 1327 EST and depicts the maximum height of 18.5 dBZ echoes or echo tops to 20,000 ft along the flight track with higher echo tops immediately east to 30,000 ft. While actual cloud tops are often higher the echo tops, the data suggests the flight was overflying the area of echoes or operating near the cloud tops at the time of the turbulence encounter.

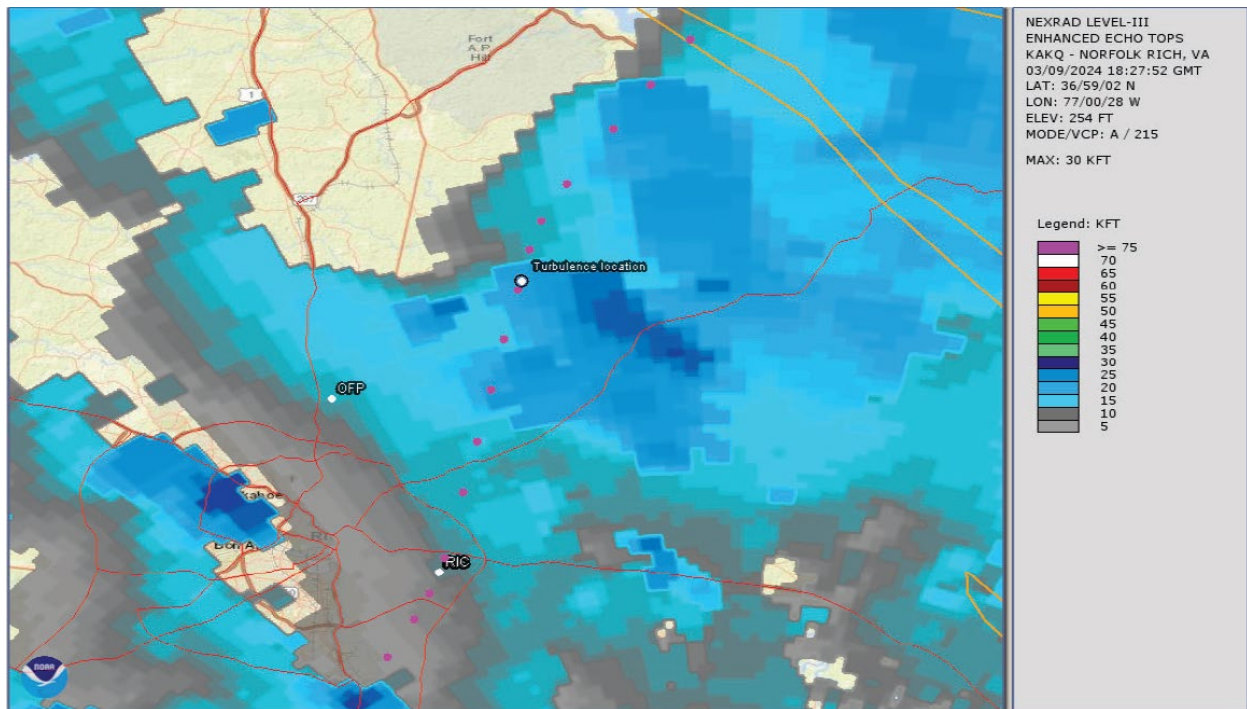


Figure 3 - NWS KAKQ WSR-88D Enhanced Echo Tops product for 1327 EST with the flight track.

A High-Resolution Rapid Refresh (HRRR) numerical model data was obtained from the NOAA Air Resources Laboratory archive for 1400 EST for the nearest grid point to the accident site. The data was then plotted on a standard SkewT/log P diagram using the RAOB Analysis software from the surface to 300-hPa or about 30,000 ft and is included as figure 4. The sounding depicted a surface temperature of 12C (54F), a dew point temperature of 11°C (52°F), with a relative humidity of 94%. The lifted condensation level (LCL) was identified at 420 ft agl, and the convective condensation level (CCCL) at 1,204 ft agl and was saturated from the LCL through 15,500 ft in nimbostratus type clouds which supported precipitation, with another band of broken to overcast higher cirriform clouds between 28,000 ft and 39,000 ft. The precipitable water content was 1.24 inches. The atmosphere was characterized as stable with a Lifted Index of 9.3 with no positive convective available potential energy (CAPE) values, while the Most Unstable Lifted Index (MULI) was 2.8. The HRRR wind profile indicated a surface wind from 140° at 8 knots, with winds veering to the west-southwest with height with increasing speeds with height. The mean 0 to 6 kilometer (or 18,000 ft) steering wind was from 230° at 44 knots, with the level of maximum wind identified at 37,000 ft from 240° at 139 knots. The tropopause height was at 39,610 ft. The wind at 23,000 ft was 245° at 62 knots, with an approximate 5.7 knots per 1,000 ft vertical wind shear at that level and a high probability of light turbulence. The HRRR sounding parameters of height, pressure (Pres), temperature (T), dew point temperature (Td), relative humidity

(RH%), wind direction and speed, Clear Air Turbulence (CAT), Low-Level Wind Shear (LLWS) and icing potential from the surface to 3,000 ft were as follows.

Heigh (ft msl)	Pres (hPa)	T (°C)	Td (°C)	RH (%)	Wind (dir/kts)	CAT (FAA)	LLWS (FAA)	Icing - Type (USAF)
157	1003	12.2	11.2	94	136/ 8			
240	1000	12.4	11.3	93	136/ 8	LGT	LIGHT	
268	999	12.3	11.4	94	138/ 11	LGT	LIGHT	
434	993	11.9	11.0	94	140/ 14	LGT	LIGHT	
684	984	11.4	10.7	95	144/ 19	LGT	LIGHT	
1077	970	10.6	10.3	98	150/ 24	LGT	LIGHT	
1590	952	9.8	9.8	100	156/ 29	MDT	LIGHT	
2228	930	9.5	9.4	99	165/ 37	MDT		
2912	907	9.5	9.5	100	172/ 45	MDT		
3675	882	9.4	9.2	99	179/ 52	SVR		
4555	854	9.1	8.5	96	193/ 53	XTR		
5594	822	8.2	6.6	90	210/ 49	LGT		
6737	788	6.4	4.4	87	213/ 46	LGT		
8029	751	4.1	2.5	89	217/ 41			
9486	711	1.7	0.7	93	218/ 40	LGT		
11131	668	-0.9	-0.9	100	217/ 49	LGT		LGT Rime
12997	622	-2.7	-2.7	100	224/ 56	MDT		LGT Rime
15118	573	-6.9	-8.3	90	238/ 58	MDT		LGT Clear
17244	527	-11.4	-18.6	55	255/ 61			
19317	485	-15.6	-58.5	1	257/ 66	LGT		
21320	447	-19.8	-45.9	8	250/ 64			
23231	413	-23.8	-38.7	24	246/ 62	LGT		
25086	382	-27.9	-38.6	35	249/ 72	MDT		
26802	355	-31.4	-40.1	42	250/ 83	MDT		
28487	330	-34.8	-40.0	59	247/ 95	MDT		
31642	287	-41.2	-43.3	80	242/ 116	LGT		

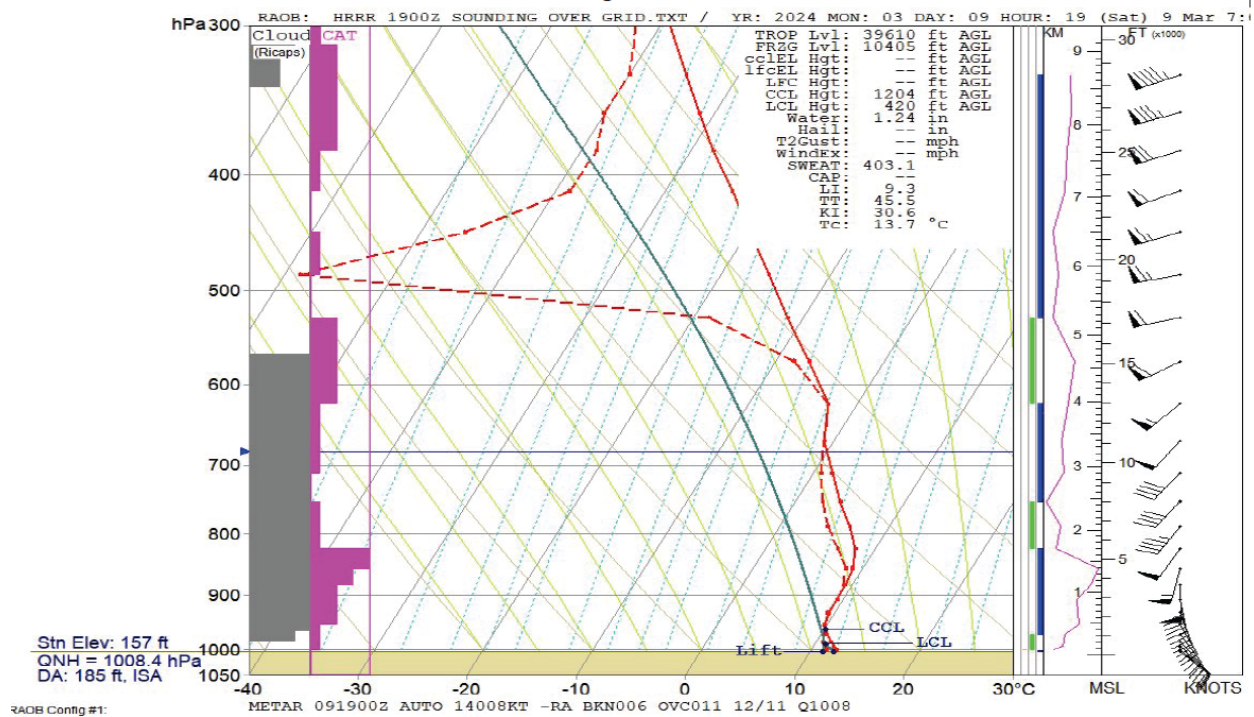


Figure 4 - HRRR numerical model sounding for 1300 EST over the closest grid point to the accident.

The NOAA Geostationary Operational Environmental Satellite number 16 (GOES-16) infrared and visible imagery were obtained from an archive at the Space Science Engineering Center (SSEC) at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. The infrared band 13 at a wavelength of 10.3 microns (μm) provided a resolution of 2 kilometers (km) with radiative cloud top temperatures, and the visible band 2 imagery at a wavelength of 0.64 μm provided a resolution of 0.5 km.

Figures 5 and 6 are the GOES-16 infrared and visible imagery for 1331 EST, which both depicted a transverse wave cloud pattern over the region with several bands of higher clouds oriented perpendicular to the wind. Transverse clouds are often observed with turbulence and indicate a wave like flow in the clouds associated with the wind field. The radiative cloud top temperature over the turbulence location was 220 kelvin or -53°C , which corresponded to cloud tops near 33,000 ft.

The map displays the flight paths of the two aircraft involved in the 2015 Alaska Airlines 261 crash. The flight from Seattle to Portland is labeled "Transverse wave pattern" and the flight from Portland to Los Angeles is labeled "Turbulence encounter". The map also shows various airports and flight numbers.

Weather Forecasts Products

High Level Significant Weather Prognostic Chart - The NWS High Level Significant Weather Prognostic Chart valid for 1900 EST is included as figure 7 and depicted two jet streams on either side of the turbulence location moving northeastward over the area. The first polar jet at FL370 had winds from 130 knots over Virginia and increasing into the ridge to 160 knots off the New England coast. The second subtropical jet from FL380 to FL400 depicted winds of 150 knots over the region. An area of moderate CAT was depicted immediately north over the New York area from FL240-FL400 associated with the polar jet stream. No turbulence or convection was depicted over the accident site.

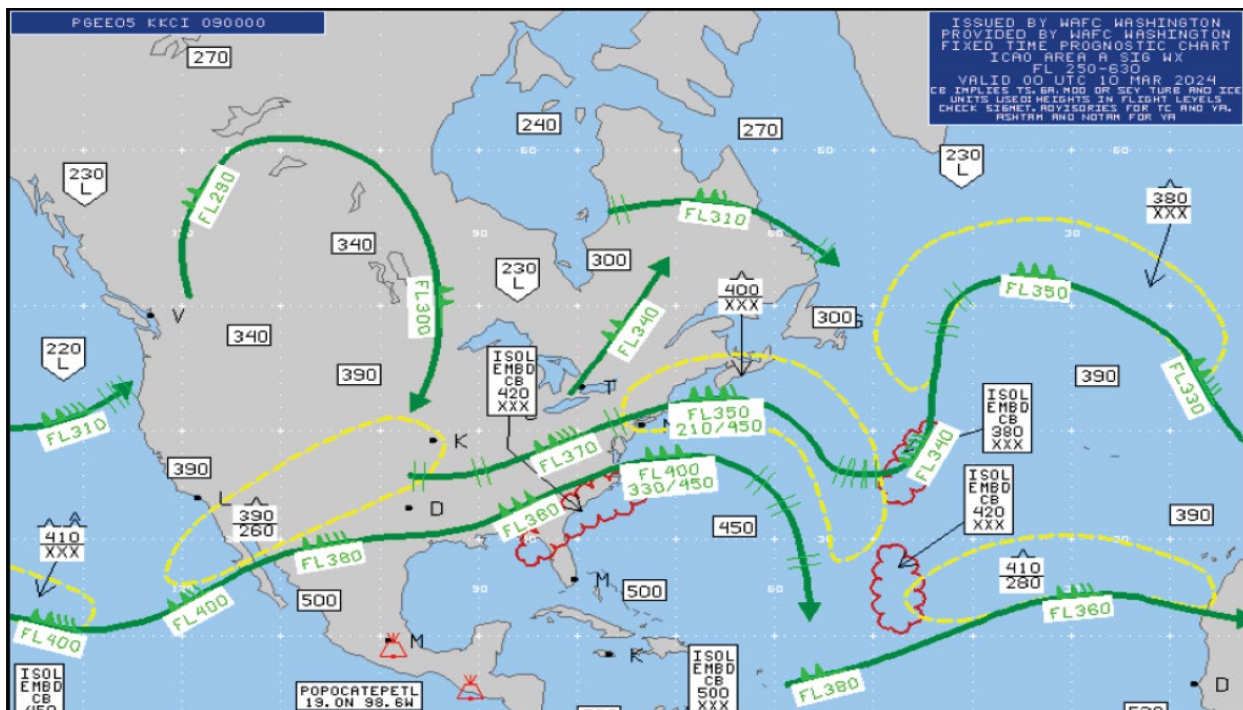


Figure 7 - NWS High Level Significant Weather Prognostic Chart valid for the period.

Graphic Turbulence Guidance (GTG) - The GTG provides a computer-generated four-dimensional forecast related to the expected intensity of atmospheric turbulence outside of any convection provided in eddy dissipation rate (EDR) as based on estimated vertical wind velocity or aircraft vertical acceleration to provide aircraft specific turbulence intensity values. The graphical turbulence grid is expressed in terms of EDR to the 1/3 power, i.e. $EDR = (m^2/s^3)^{1/3}$. The NWS defines the following EDR values to various aircraft weight classes and turbulence intensities, the Boeing B737 fits the medium weight class. The estimated EDR thresholds below are multiplied by x100,

as EDR values are depicted in the range from near 0 (typically smooth) to 100 (typically “extreme” for most aircraft). Figures 8 and 9 are the GTG for FL240 for 1300 and 1400 EST centered over Virginia, which shows an area of EDR's between .20 to .40 consistent with moderate turbulence moving northeastward surrounding the period.

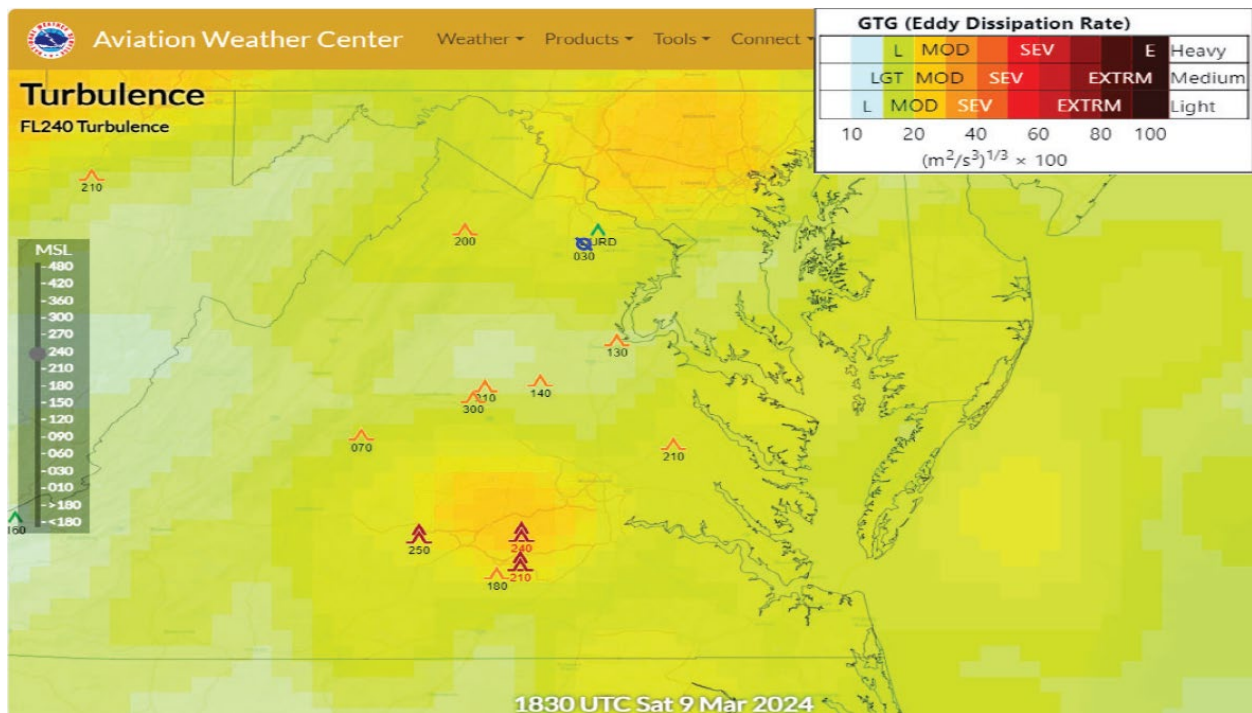


Figure 8 - Graphic Turbulence Guidance (GTG) for 1300 EST with PIREPs, with an area of EDR values of .20 to .40 over Virginia

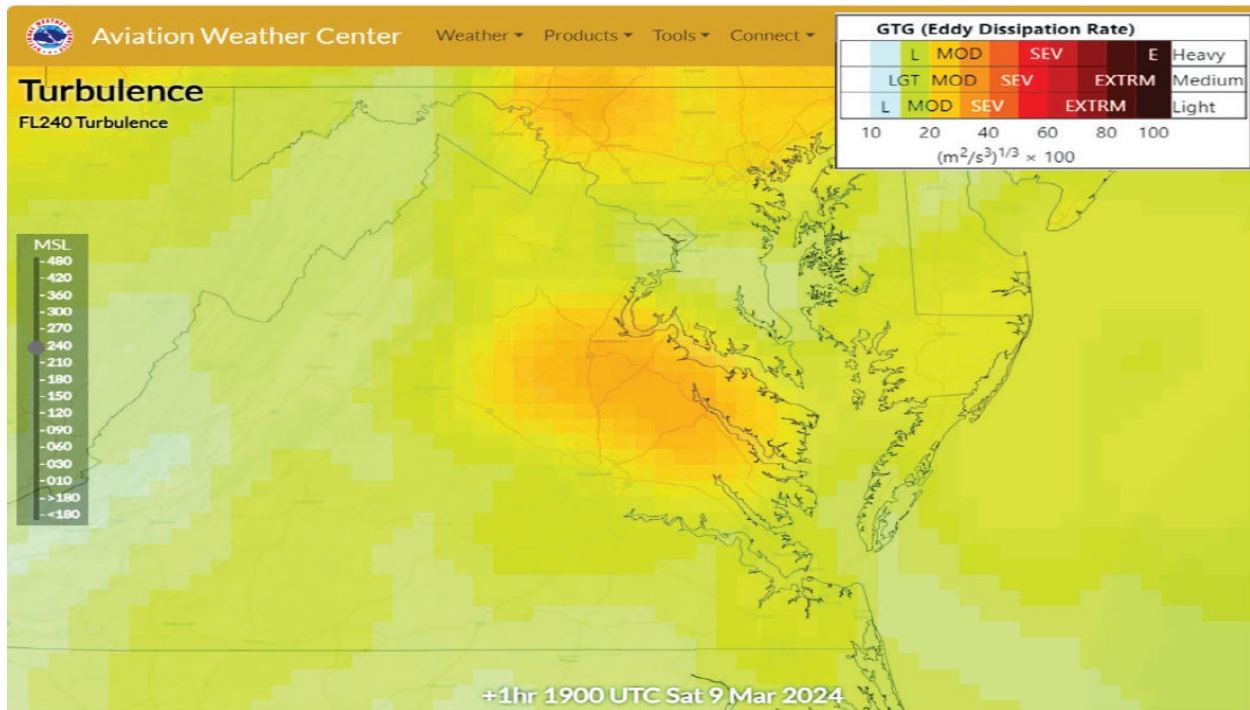


Figure 9 - GTG for 1400 EST for FL240 showing an area of EDR values of .20 to .40 over the accident site.

Inflight Weather Advisories - No SIGMETs, Convective SIGMETs or Center Weather Advisories (CWA). The NWS had Graphic-AIRMET current for IFR conditions, icing conditions, and occasional moderate turbulence between the surface and 8,000 ft over the entire east and between 18,000 ft coast and 38,000 ft, and low-level wind shear (LLWS) below 2,000 ft agl. Figure 10 is a depiction of the G-AIRMET Tango series current at the time of the accident, which included an advisory for occasional moderate turbulence between FL180 to FL380 over the region.

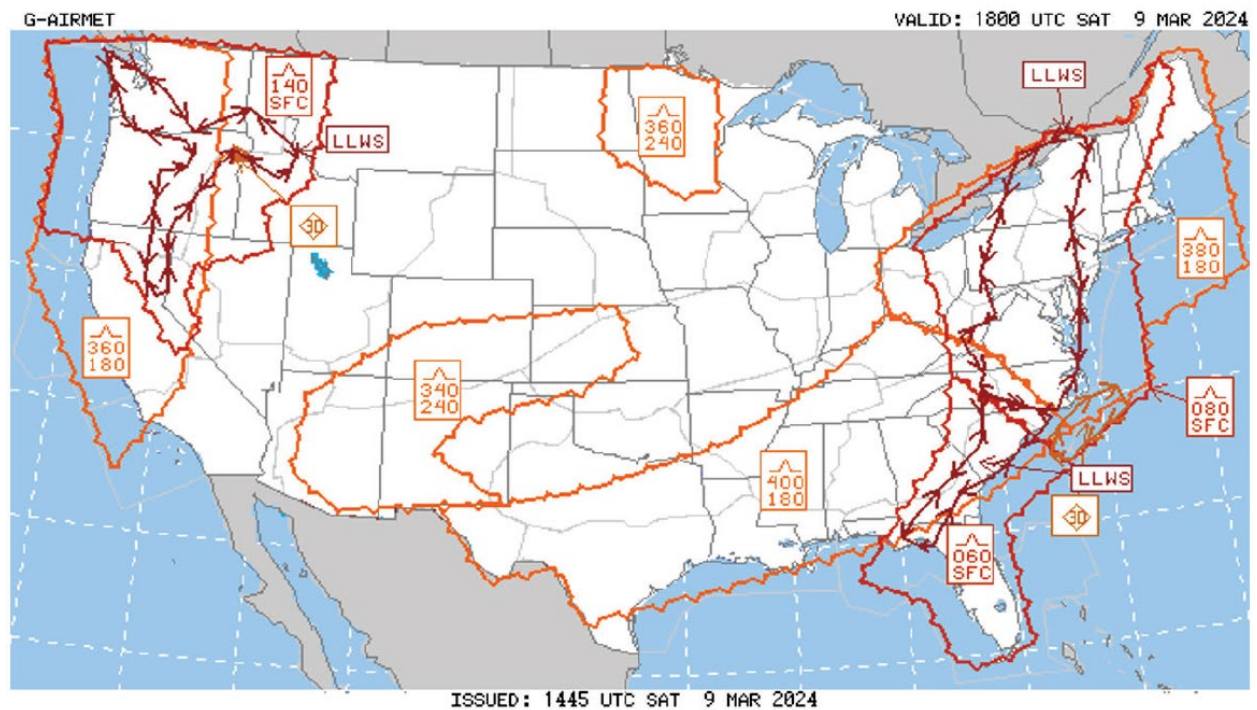


Figure 10 - Graphic-AIRMET Tango series advisories current during the period. Occasional moderate turbulence FL180-FL380