National Transportation Safety Board

Office of Aviation Safety

Washington, D.C. 20594-2000

June 21, 2011

WEATHER STUDY

WPR11LA203

A. ACCIDENT

Location: Pacific Ocean
Date: April 11, 2011
Time: 0658 Coordinated Universal Time (UTC)
Aircraft: American Airlines Flight 170, Boeing 777-223; registration N766AN

B. METEOROLOGICAL SPECIALIST

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C. SUMMARY

On April 11, 2011, at 0700 coordinated universal time (UTC), American Airlines Flight 170, a Boeing 777-223, N766AN, experienced severe turbulence during climb over international waters about 194 nautical miles east of Narita, Japan. Four flight attendants were injured; two flight attendants sustained minor injuries, while two flight attendants sustained serious injuries. There were no injuries to the other 227 passengers and crew, and the airplane was not damaged. The scheduled international passenger flight originated from Narita International Airport, Narita Japan and was en route to Los Angeles International Airport, Los Angeles, California under the provisions of Title 14 Code of Federal Regulations Part 121.

A representative from American Airlines reported that during climb as the airplane passed through 24,000 feet, the aircraft experienced approximately 10-15 seconds of severe turbulence. The two flight attendants who received serious injuries were located in or near the aft galley at the time the airplane encountered the turbulence.

D. DETAILS OF INVESTIGATION

The National Transportation Safety Board's (NTSB) Senior Meteorologist was not on scene for this investigation and gathered all the weather data for this investigation from the Washington D.C. office from official National Weather Service (NWS) sources including the National Climatic Data Center (NCDC). All times are based upon the 24 hour clock, and UTC=Z. Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident site was located at latitude 35.8933° N and longitude 143.8716° E, at 24,000 feet.

1.0 Synoptic Situation

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction (NCEP) located in Camp Springs, Maryland. These are the base products used in describing weather features and in the creation of forecasts and warnings. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC 00-45.

1.0.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 0600Z on April 11, 2011 is provided as figure 1, with the approximate location of the accident site marked by a circled red "X". The chart depicted a developing low pressure system at 1004-hectopascals (hPa) along a frontal wave located on the eastern coast of Japan, with a cold front extending southwest from the low and a warm front to the east-northeast. The accident site was located immediately east of the low pressure system and in the vicinity of the warm front in the warm air sector of the front. The movement of the low was depicted east-northeastward towards the accident location with a developing gale conditions or winds of 34 to 47 knots off the coast of Japan. Another low pressure system at 1005-hPa was located northeast of the accident site with a cold front extending southwestward east of the accident site.

The station models located in the vicinity of the accident site indicated southwesterly winds of 15 to 20 knots.

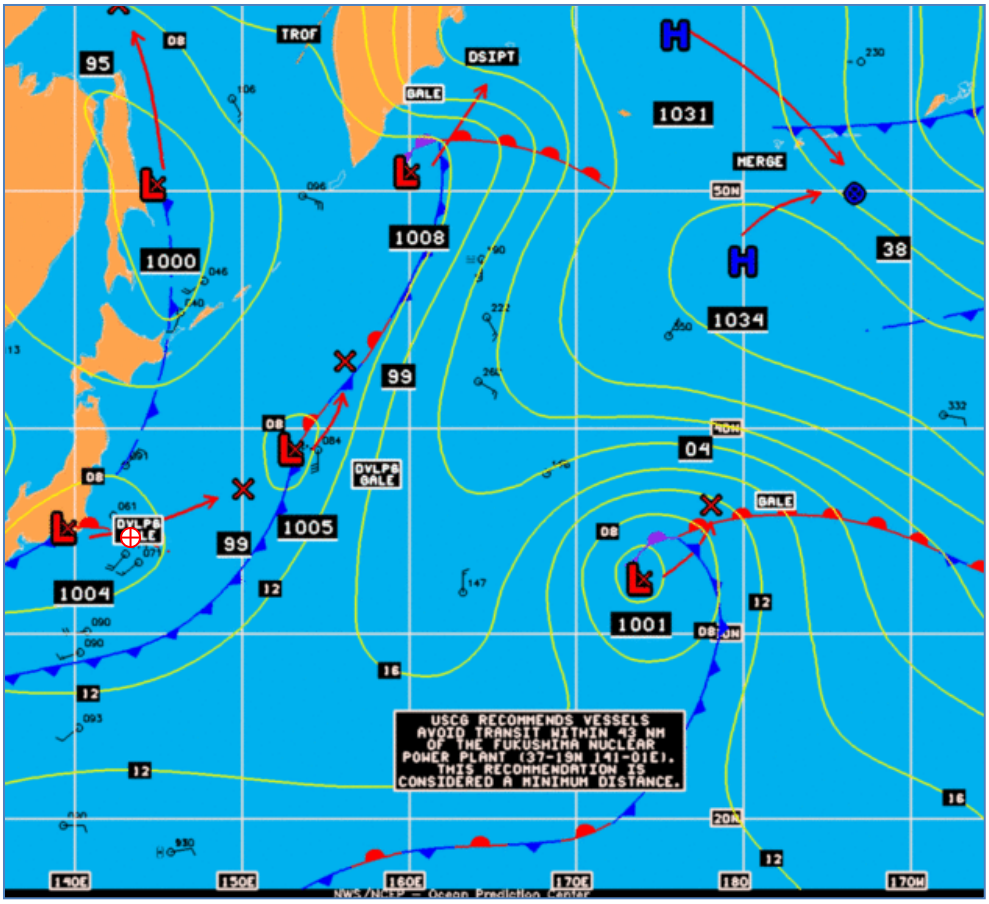

Figure 1 – NWS Surface Analysis Chart for 0600Z

1.0.2 Upper Air Charts

The NWS Constant Pressure Charts for 500-hPa or approximately 18,000 feet for 0000Z and 1200Z on April 11, 2011 are included as figures 2 and 3 respectively. The charts depicted a trough of low pressure extending over Japan with the accident site located ahead of the trough in an area of favorable upper level divergence with winds from the west-northwest from 40 to 45 knots.

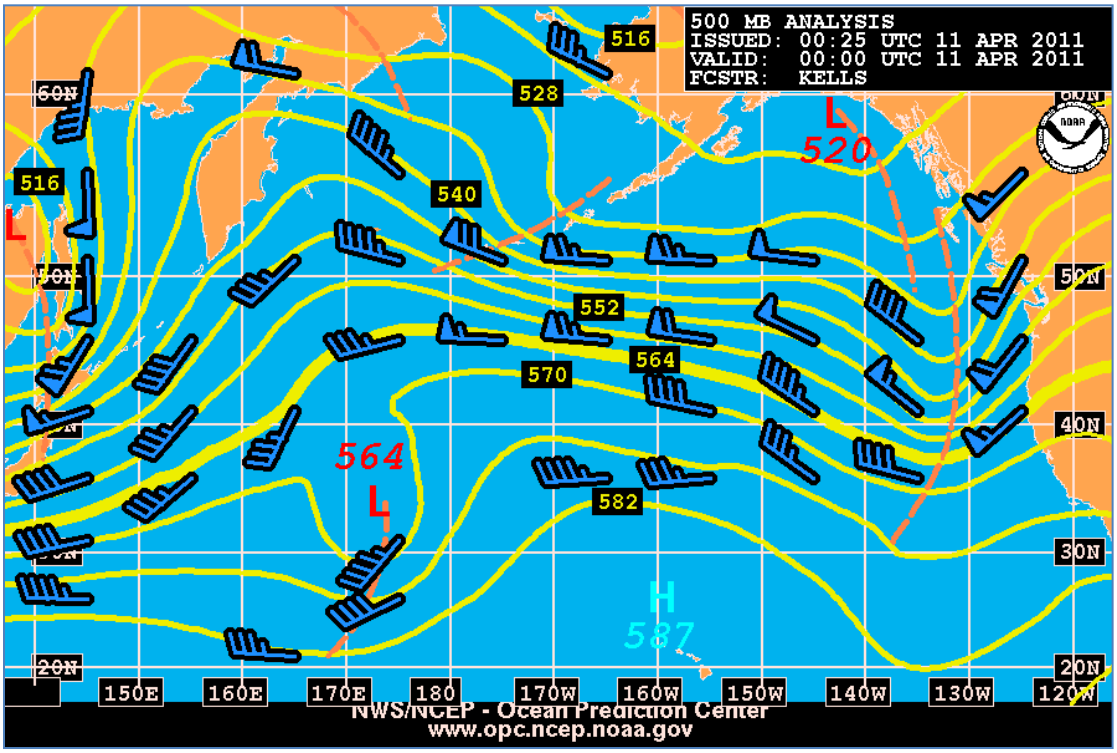

Figure 2 – 500-hPa for 0000Z on April 11, 2011

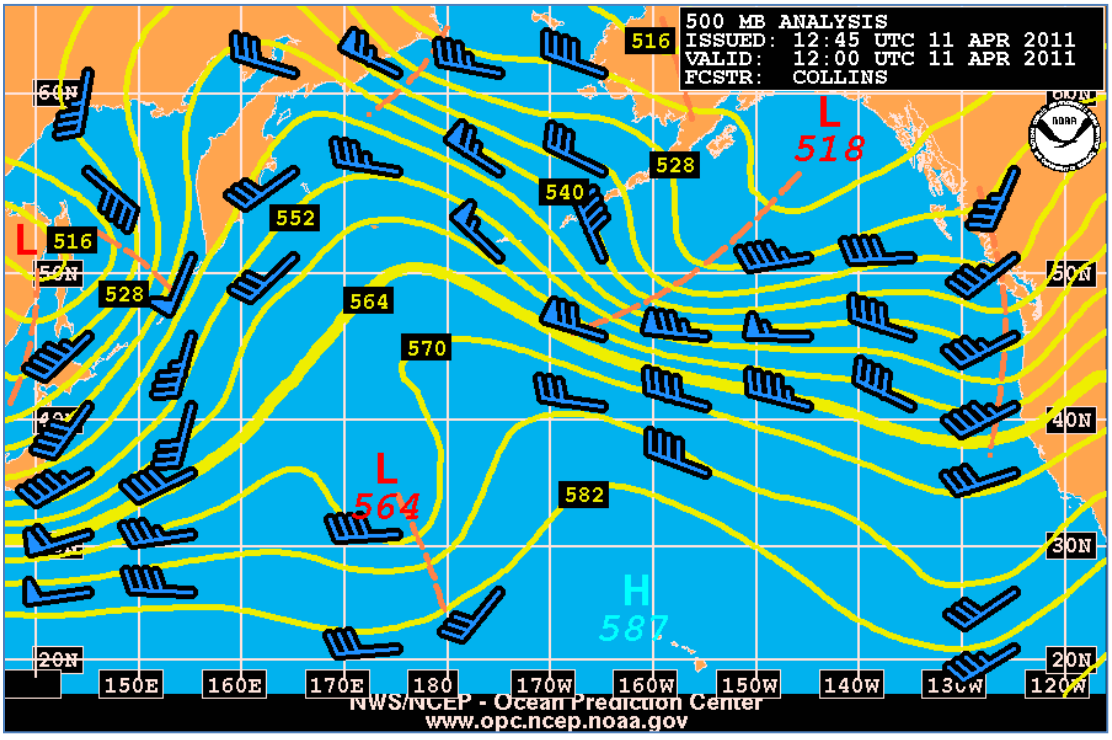

Figure 3 – 500-hPa for 1200Z on April 11, 2011

2.0 Terminal Conditions

Narita International Airport (RJAA)[1] reported the following weather conditions surrounding the period:

RJAA 110200Z 28003KT 220V010 9999 -SHRA SCT030 BKN040 15/09 Q1008 BECMG 20005KT RMK 4CU030 7CU040 A2978

RJAA 110300Z 06004KT 9999 FEW030 BKN040 15/10 Q1007 BECMG 12005KT RMK 2CU030 6CU040 A2974 0233 MOD TURB 7000FT 5NM S NARITA B777

RJAA 110400Z 08004KT 9999 FEW030 SCT035 BKN/// 17/09 Q1006 NOSIG RMK 1CU030 4CU035 A2972

RJAA 110500Z 11011KT 9999 FEW030 BKN/// 18/08 Q1005 NOSIG

RJAA 110600Z 14012KT 9999 FEW030 BKN/// 18/02 Q1004 NOSIG RMK 1CU030 A2966

RJAA 110630Z 12011KT 070V170 9999 FEW030 BKN/// 17/05 Q1004 NOSIG RMK 1CU030 A2965

Accident at 0658Z

RJAA 110700Z 13009KT 9999 FEW030 BKN/// 17/07 Q1003 TEMPO 4000 -TSRA RMK 1CU030 A2964 0654 MOD TURB BTN 8000FT AND 7000FT 30NM N NARITA B737

RJAA 110800Z 11007KT 9999 FEW030 BKN/// 16/09 Q1003 TEMPO 4000 TSRA RMK 1CU030 A2964

RJAA 110900Z 09003KT 9999 FEW020CB SCT100 BKN/// 14/09 Q1004 TEMPO 4000 TSRA RMK 1CB020 3AC100 A2965 CB 70KM N MOV SE

RJAA 111000Z 31003KT 240V010 9999 FEW020CB BKN070 BKN/// 14/07 Q1004 TEMPO 02018G30KT 4000 TSRA RMK 1CB020 5AC070 A2967 CB 70KM N MOV E

RJAA 111100Z 04016KT 9999 FEW015 SCT080 BKN130 10/08 Q1006 WS R34L TEMPO 02021G33KT 4000 TSRA RMK 1CU015 3AC080 7AC130 A2971

RJAA 111200Z 03019KT 9999 FEW008 BKN010 BKN020 09/07 Q1007 TEMPO 02021G33KT RMK 1ST008 5ST010 7CU020 A2975

The RJAA reported generally VFR conditions during the period with temporary periods of MVFR ceilings and visibilities in thunderstorms and rain showers. Wind was variable during the period with multiple layers of clouds with general broken cloud cover. Prior to and after the accident, several pilot reports of moderate turbulence were reported in the vicinity of the airport by air carrier aircraft (B737 and B777).

The Terminal Aerodrome Forecasts (TAFs) for RJAA surrounding the period were as follows:

TAF TAF RJAA 110242Z 1103/1206 14008KT 9999 FEW025 BKN040
TEMPO 1107/1110 4000 -TSRA FEW015CB BKN020
BECMG 1110/1112 36016KT
TEMPO 1112/1115 36020G32KT

[1] Narita International Airport - IATA code NRT, ICAO code RJAA.

The forecast expected from 0700Z to 1000Z a temporary period of visibility 4000 meters (2 1/2 statute miles) in thunderstorms and light rain with a few cumulonimbus clouds at 1,500 feet, ceiling broken at 2,000 feet. The next forecast issued at 0852Z continued to expected disturbed weather in the area as follows:

TAF RJAA 110852Z 1109/1212 12005KT 8000 SCT015 BKN030
BECMG 1109/1110 33013KT
TEMPO 1109/1111 02021G33KT 4000 TSRA SCT010 FEW015CB BKN020
TEMPO 1111/1117 02021G33KT

3.0 Upper Air Sounding

The closest upper air sounding or rawinsonde observation (RAOB) was from the Japanese Meteorological Agency's (JMA) Tateno, site number 47646, located approximately 168 miles west of the accident site at an elevation of 102 feet msl. The 1200Z sounding on April 11, 2011, from Tateno plotted on a standard Skew-T log P diagram[2] utilizing RAOB[3] software from the surface to 300-hPa or approximately 30,000 feet is included as figure 4. The sounding depicted the condition in the cold air side of the front or west of the low and frontal system. The sounding depicted a moist low-level environment with the lifted condensation level (LCL)[4] at 962-hPa or at 1,193 feet agl, and a convective condensation level (CCL)[5] at 862-hPa or 4,100 feet agl. At 3,545 feet a frontal inversion was noted, between 22,000 and 24,000 feet an isothermal layer was also noted where temperature did not change with altitude, and abrupt drying above. The sounding had a relative humidity of 75 percent or more from the surface to approximately 22,000 feet, with a precipitable water value was 0.72 inches. The freezing level was identified at 5,290 feet and the sounding supported icing conditions through 22,000 feet. The tropopause height was identified at 286-hPa or 30,663 feet. At 24,000 feet, the sounding indicated a wind from 260° at 58 knots with a temperature of -38° C.

[2] Skew T log P diagram – is a standard meteorological plot using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

[3] RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamopras, Pennsylvania.

[4] Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

[5] Convective Condensation Level (CCL) - The height to which a parcel of air, if heated sufficiently from below, will rise adiabatically until condensation starts. This is typically used to identify the base of cumuliform clouds, which are normally produced from surface heating and thermal convection.

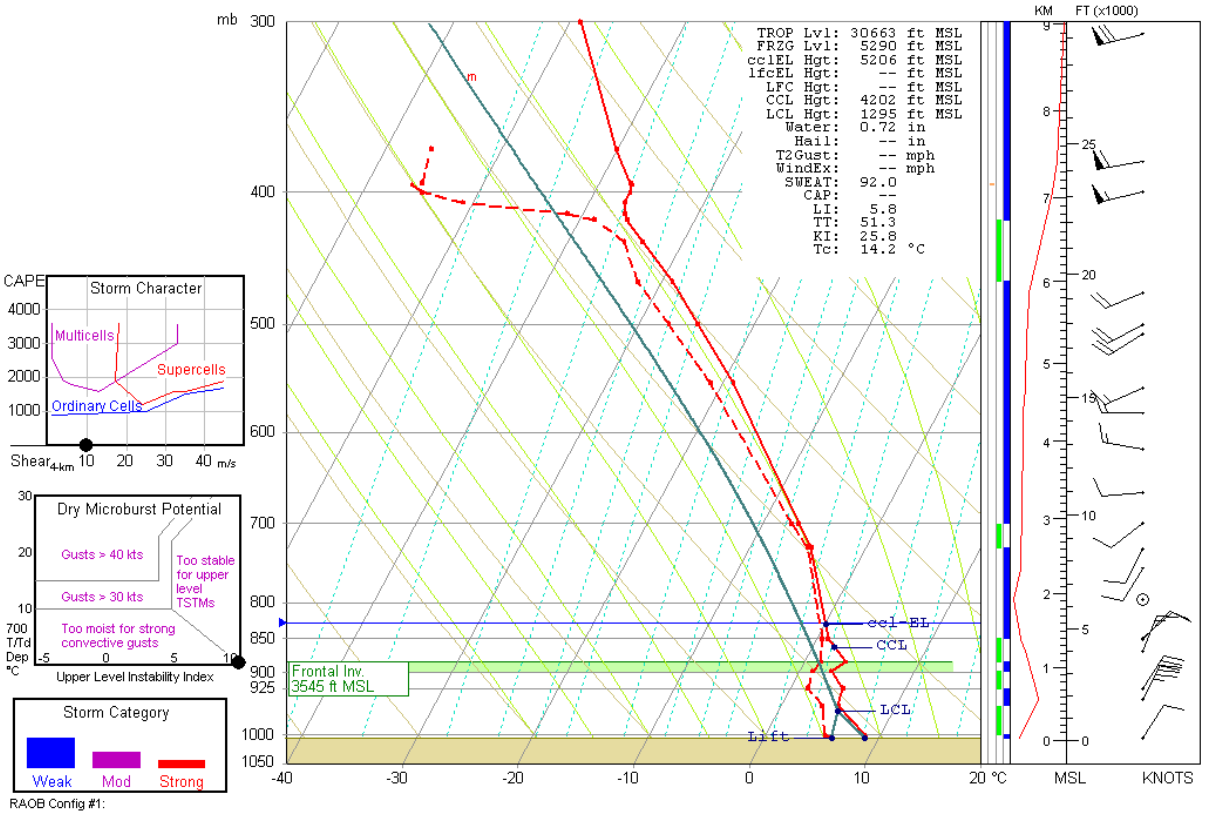

Figure 4 – Tateno, Japan sounding for 1200Z

The sounding indicated a stable atmosphere with a Lifted Index (LI)[6] of 5.8 and a most unstable (MU) lifted index of 3.7, the stability of the atmosphere is indicated by a color bar on the right axis (blue – stable, green – conditional unstable, yellow – unstable). The K-index[7] of 25.8 indicated a 40 percent chance of air mass type thunderstorms.

The sounding wind profile indicated surface wind from 030° at 8 knots with wind speeds increasing to 34 knots at 1,800 feet below the frontal inversion associated with a low-level wind maximum and then decrease and shifting abruptly to the southwest and veering to the west with height above 6,000 feet. The low level wind field indicated the low pressure system was located east of the station. The level of maximum wind was identified in the stratosphere at 34,495 feet with a wind from 265° at 88 knots (the previous 0000Z sounding indicated a wind maximum from 260° at 112 knots at 40,000 feet). The mean 0 to 6 kilometer (km) wind was from 270° at 8 knots.

[6] Lifted Index (LI) - A common measure of atmospheric instability. Its value is obtained by computing the temperature that air near the ground would have if it were lifted to some higher level (around 18,000 feet, usually) and comparing that temperature to the actual temperature at that level. Negative values indicate instability - the more negative, the more unstable the air is, and the stronger the updrafts are likely to be with any developing thunderstorms.

[7] K-Index - The measure of thunderstorm potential based on the vertical temperature lapse rate, the moisture content of the lower atmosphere and the vertical extent of the moist layer. The higher the K-Index, the greater the probability of air mass type thunderstorms development.

4.0 AMDAR Aircraft Report

A meteorologically instrumented aircraft identified as flight #9644, descended into Narita International Airport from the east and followed a similar flight track as the accident airplane, and landed at 0732Z. The Aircraft Meteorological Data Relay (AMDAR) descent sounding is included as figure 5 followed by the reported elements of the report. The aircraft reported a wind from approximately 245° at 65 knots and a temperature of -34° C.

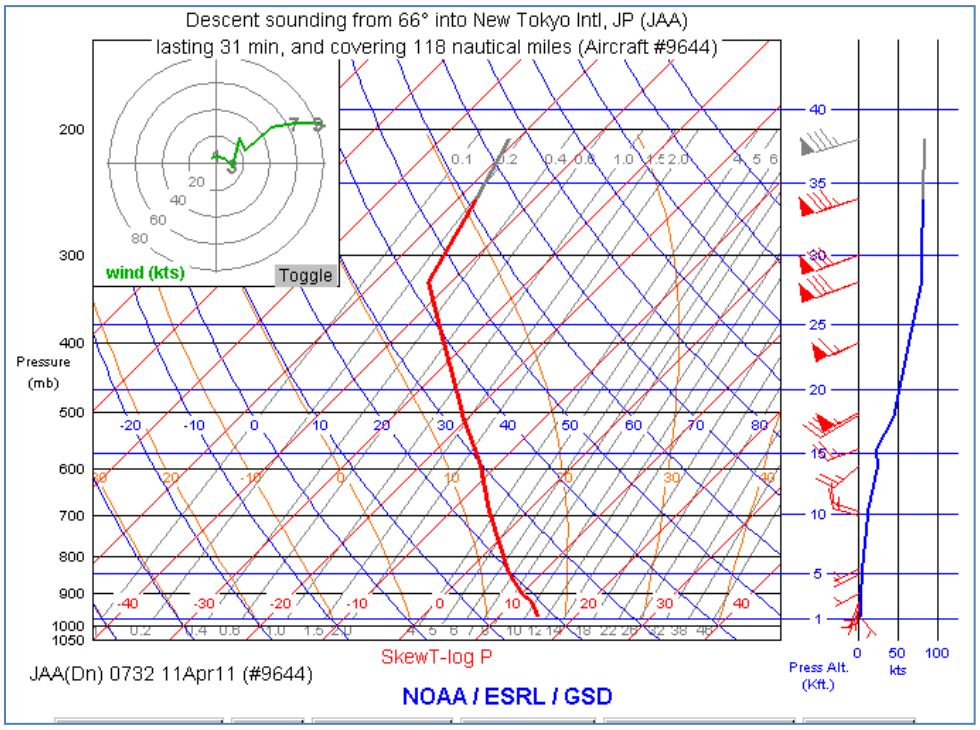

Figure 5 – AMDAR sounding at 0732Z

JAA(Dn) 0732 11Apr11
Descent sounding from 66° into New Tokyo Intl, JP (JAA)
lasting 31 min, and covering 118 nautical miles (Aircraft #9644)

P_alt (ft)	mb	t/td (°C)	w_dir/w_spd (kts)	Time (UTC)	Bng/Rng (nm)
1270	968	15.0/-----	137°/004	0732	340°/004
1770	950	14.0/-----	202°/005	0731	337°/006
2270	933	13.0/-----	184°/005	0729	337°/011
2499	925	12.3/-----	197°/005		
3260	899	10.0/-----	238°/005	0728	348°/012
4779	850	6.2/-----	242°/007		
5270	835	5.0/-----	243°/007	0726	20°/012
9876	700	-4.2/-----	283°/013		
10270	690	-5.0/-----	286°/014	0720	101°/023
14000	595	-12.0/-----	226°/026	0716	85°/040
15320	564	-15.0/-----	248°/024	0713	89°/054
18000	506	-21.0/-----	238°/047	0712	88°/062
18278	500	-21.6/-----	238°/048		
23470	400	-32.9/-----	244°/065		
28120	328	-43.0/-----	249°/081	0708	82°/085
30001	300	-44.5/-----	250°/082		
33904	250	-47.7/-----	251°/083		
38000	206	-51.0/-----	252°/085	0701	66°/118

5.0 Satellite Data

The JMA's geostationary meteorological satellite (MTSAT-2) data was obtained from the University of Wisconsin's Space Science and Engineering Center (SSEC) and displayed on the National Transportation Safety Board's Man-computer Interactive Data Access System (McIDAS) workstation. Both visible and infrared imagery was obtained surrounding the time of the accident. The infrared imagery (band 2) at a wavelength of 10.8 microns (μm) provided a 5 km resolution with radiative cloud top temperatures. The visible imagery (band 1) at a wavelength of 0.73 μm provided a resolution of 1.25 km. The satellite imagery surrounding the time of the accident from 0600Z through 0700Z, at approximately every 30 minutes were reviewed and the closest images documented below.

Figures 6 and 7 are the MTSAT-2 infrared (band 2) images at 0632Z and 0702Z respectively with a standard MB temperature enhancement curve applied to highlight the higher and colder cloud tops associated with deep convection. The accident site is marked by a white square on the images. The images depict an area of low to mid-level clouds over the accident site with a small area of enhanced clouds approximately 50 miles west-southwest of the accident site associated with cumulonimbus clouds. Other enhanced areas are noted over 150 miles west through north-northeast over northern Japan and off the coast and 300 miles to the northeast through east. The radiative cloud top temperature over the accident site was observed at 260° Kelvin (K) or –15° C, which corresponded to cloud tops near 14,000 feet. The enhanced area west-southwest of the accident site and immediately upwind of the accident site had a cloud top temperature of 231° K or -42° C, which corresponded to tops near 26,000 feet.

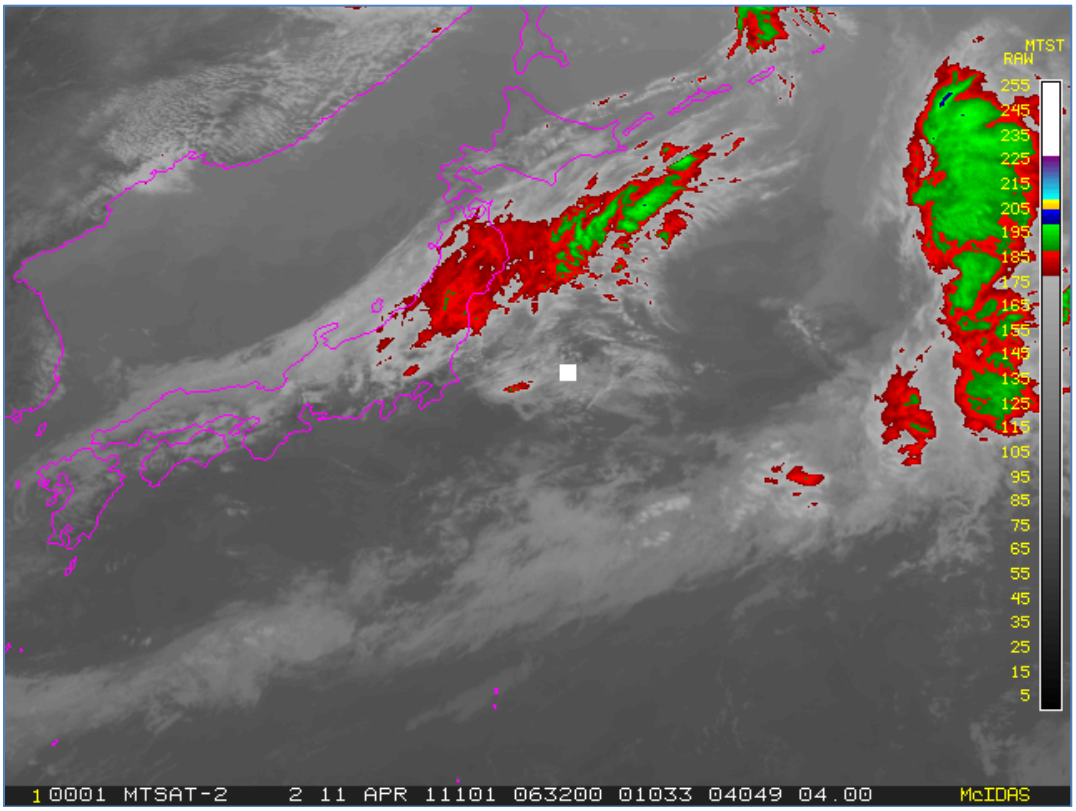

Figure 6 – MTSAT infrared image at 0632Z

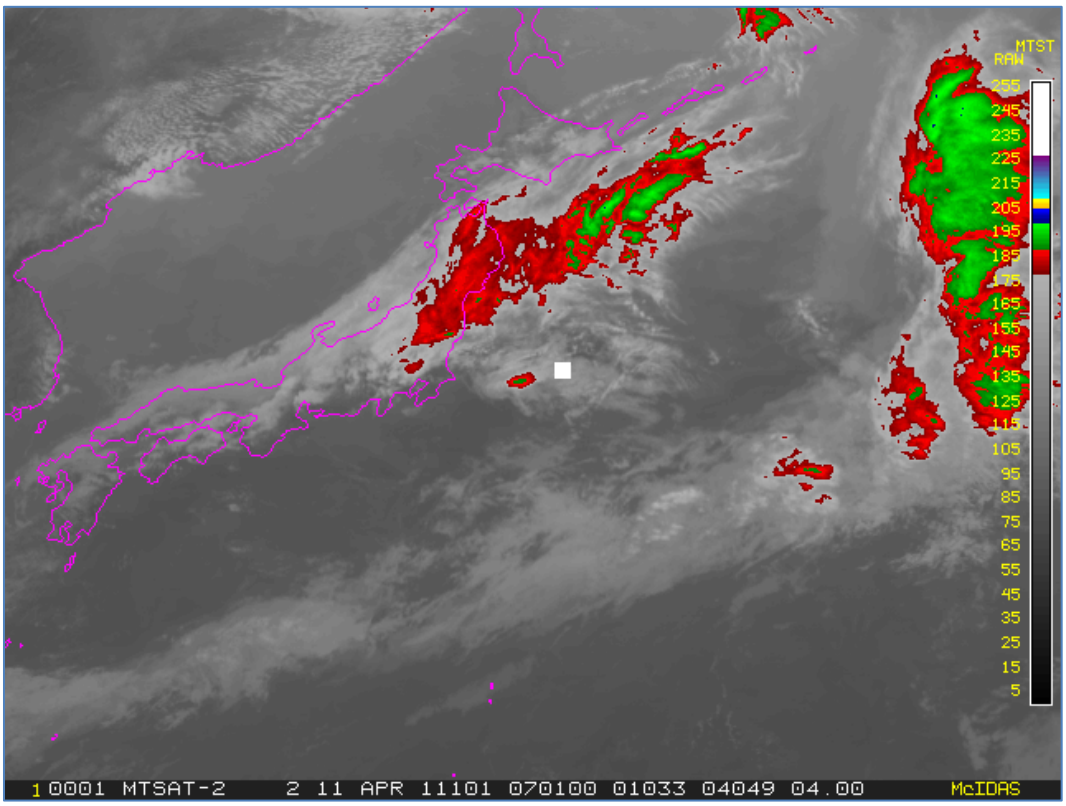

Figure 7 – MTSAT-2 infrared image at 0701Z

Figures 8 through 10 are the MTSAT visible images at 0632Z, 0701Z, and 0732Z respectively at 2X magnification over the accident site. The images depict the accident site over a low to mid-level altostratus cloud layer and downstream of an area of cumulus to cumulonimbus clouds, which eventually shows anvil blow off extending over the accident site by 0732Z. The clouds associated with the anvil bluff moving over the accident site implies the turbulence encountered by American Airlines flight 170 was likely related to convectively induced turbulence (CIT) and not clear air turbulence (CAT) which is typically associated with the jet stream.

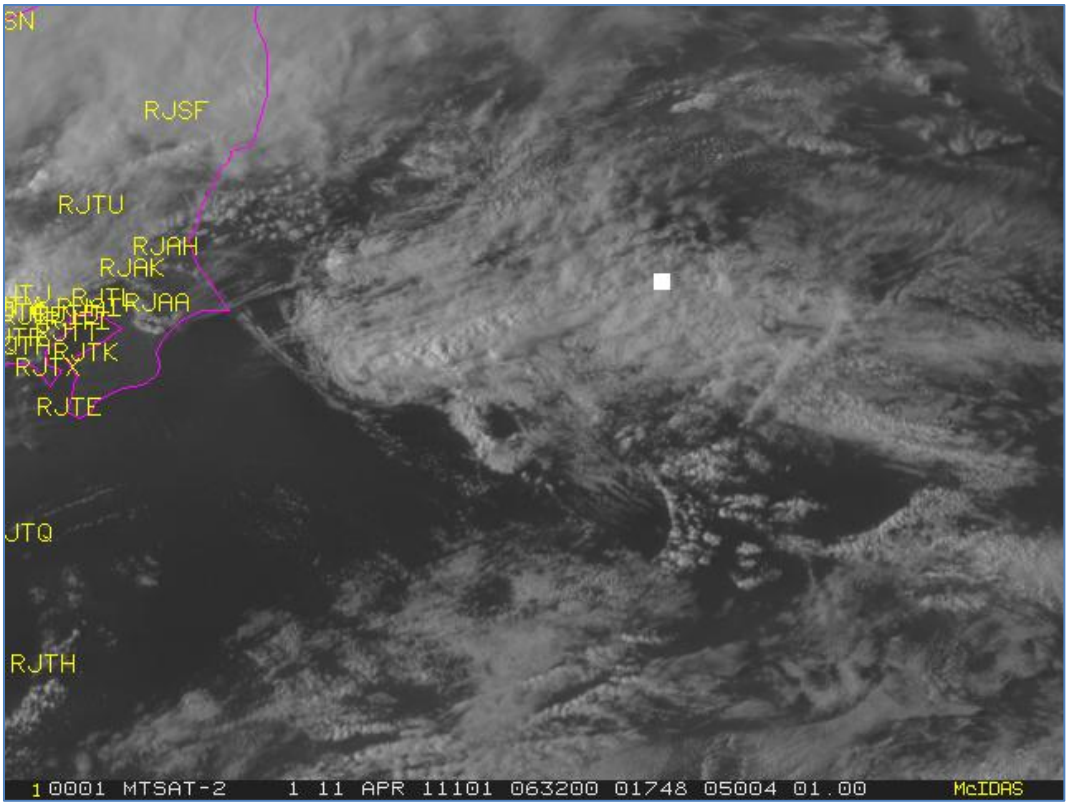

Figure 8 – MTSAT visible image at 0632Z

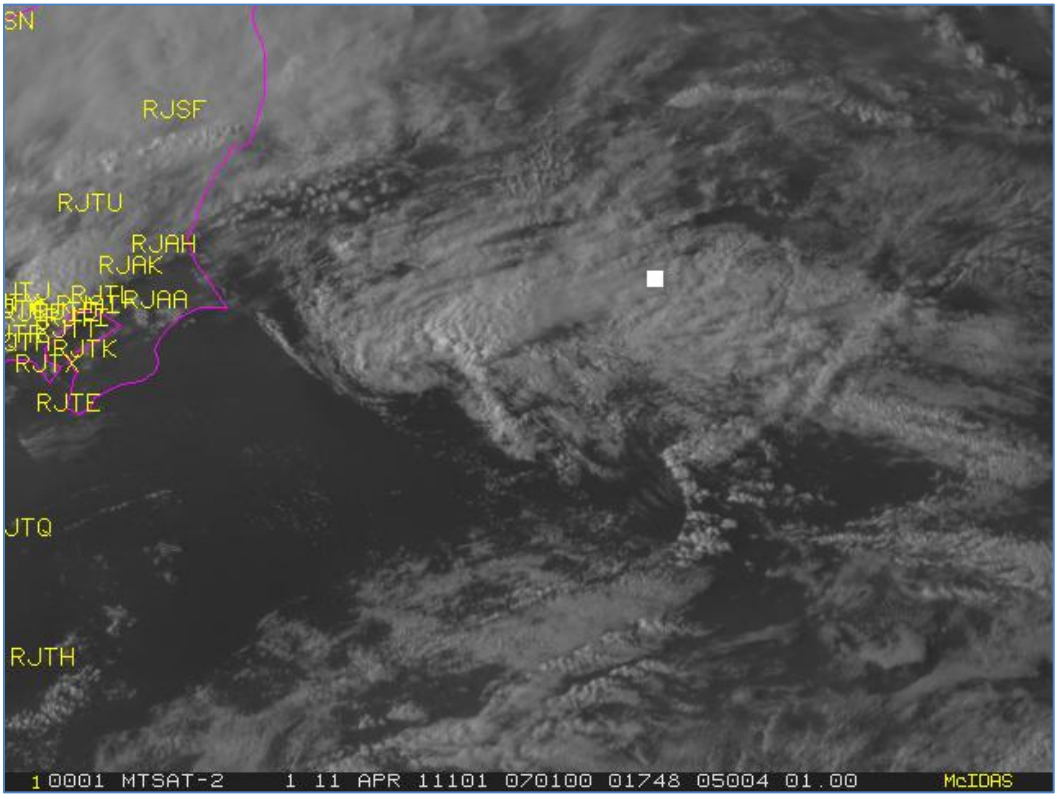

Figure 9– MTSAT visible image at 0701Z

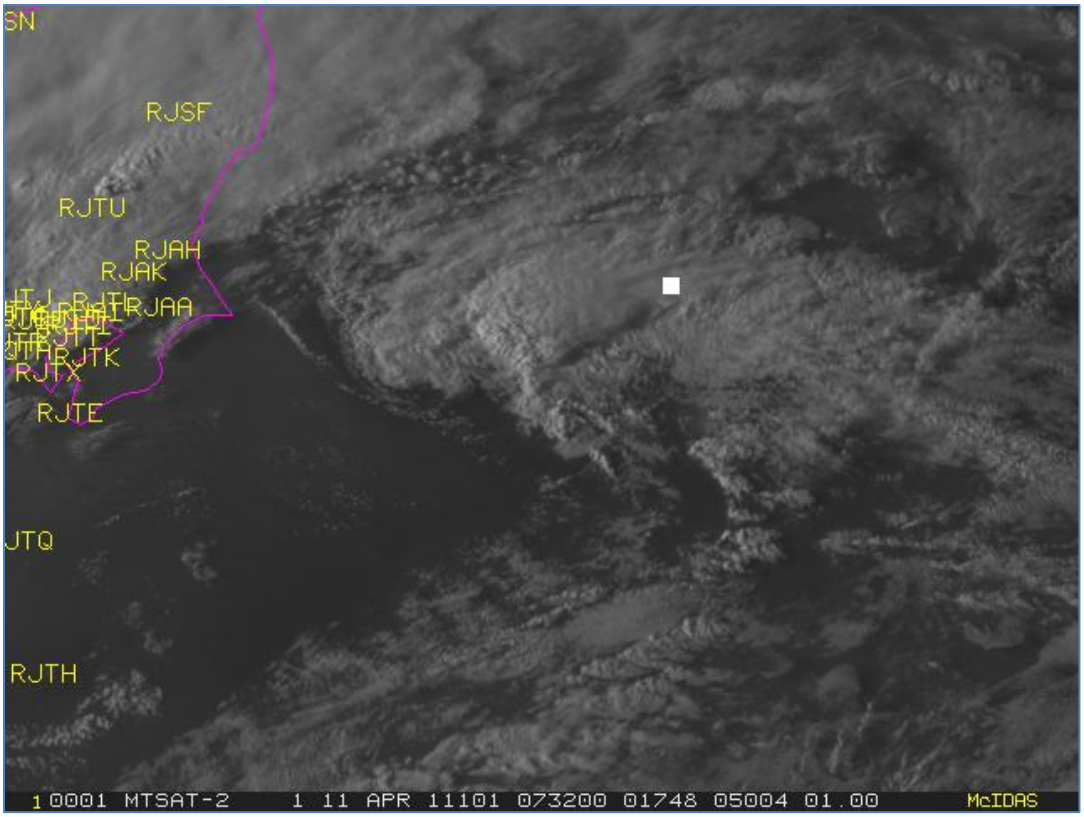

Figure 10 – MTSAT visible image at 0732Z

7.0 Weather Document

A copy of the weather document issued to the flight is included as attachment 1. The document provided the latest METAR and TAFs for the departure, destination, and alternate airports, and notice to airmen. No SIGMETs were current for the route of flight indicating any significant convection, turbulence, or icing was expected for the route.

8.0 Pilot Statements

The Captain of flight 170 indicated in his written statement that they were climbing through 24,000 feet at 0700Z in visual meteorological conditions (VMC) with a small buildup at their 12 o'clock position when they encountered 10 to 15 seconds of moderate to severe turbulence. The captain indicated they attempted to obtain a clearance to deviate from Tokyo control prior to the encounter without success. He further stated that the airborne weather radar did not "paint" any returns or depict any echoes. He did not specify what mode or tilt the radar was set and was vague regarding if the aircraft entered into the "small buildup" or over flew the towering cumulus clouds. He also indicated the fasten seat belt sign was still on at the time of the turbulence encounter.

The First Officer's statement also indicated that they attempted to obtain a clearance to deviate around the weather buildup and were advised to stand by when the airplane entered into

the weather at 0700Z, when they encountered the moderate to severe turbulence. His statement indicated they had penetrated the "build up" or towering cumulus clouds when the turbulence event occurred. He also indicated that the onboard weather radar depicted no echoes and that the seat belt sign was on. It was after clearing the weather when the purser called and advised them of the injured flight attendants.

None of the flight attendants statements mentioned weather conditions, other than they had previously been briefed that no significant turbulence was anticipated for the flight.

9.0 Flight Data Recorder (FDR) Data

The FDR data indicated that the vertical accelerations went from 1 g normal loading to a maximum of 2.2 and then to a minimum of 0.49 g's for a total variation of 1.71 g's during the period, which fits the international standard for severe turbulence (1.0 to 1.99 vertical g's).

Donald Eick
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