# FINAL REPORT

**AAIU Synoptic Report No: 2007-018**
**AAIU File No: 2006/001**
**Published: 10/09/07**

**In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Air Accidents, on 1/3/06, appointed Mr. John Hughes as the Investigator-in-Charge to carry out a Field Investigation into this Serious Incident and prepare a Synoptic Report.**

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|---|---|
| **Aircraft Type and Registration:** | Airbus A330-202, EI-DAA |
| **No. and Type of Engines:** | 2 x CF6 80 E1A4 |
| **Aircraft Serial Number:** | 397 |
| **Year of Manufacture:** | 2001 |
| **Date and Time (UTC):** | 2 January 2006 @ 18.42 hrs |
| **Location:** | 35° West Longitude |
| **Type of Flight:** | Scheduled Public Transport |
| **Persons on Board:** | Crew - 2 & 10 Passengers - 258 |
| **Injuries:** | Crew - 6 Passengers - Nil |
| **Nature of Damage:** | None |
| **Commander's Licence:** | ATPL |
| **Commander's Details:** | Male, aged 45 years |
| **Commander's Flying Experience:** | 13,415 hours, of which 270 were on type |
| **Notification Source** | SOTS Incident Report. |
| **Information Source:** | AAIU Investigation |

## SYNOPSIS

EI-DAA was cruising at FL 380 in smooth conditions with no turbulence reported. During the cruise, at 35° West Longitude, the aircraft received several severe jolts, which caused the autopilot to disengage. The Captain immediately took control of the aircraft. The seat belt sign had not been switched on before the encounter, but was switched on immediately the turbulence started. For approximately one minute the aircraft experienced moderate turbulence, with the aircraft flown in manual control. When the turbulence eased the autopilot was re-engaged. The Cabin Manager advised the Captain that six crewmembers were injured during the turbulence. On arrival into JFK, five of the injured crewmembers were taken to see the company doctor. The injuries to the Cabin Crew were not considered serious. Seven of the crewmembers operated back to Dublin the following day and the remaining three positioned home on the same flight.

# FINAL REPORT

## 1. FACTUAL INFORMATION

### 1.1 History of the Flight

EI-DAA was operating from Dublin to New York. At approximately 18.40 hrs, two and a half hours into the flight, the bar and meal service in economy were completed and the cabin crew at the back of the aircraft were setting up the duty free carts. The aircraft was cruising at FL 380 in smooth conditions with no turbulence reported. As the aircraft passed 35° West Longitude, in mid-ocean, the aircraft was hit by sudden and severe turbulence, which caused the autopilot to disengage. The Captain immediately took control of the aircraft and reduced the thrust to achieve the recommended turbulence penetration speed of Mach 0.78. The turbulence was felt through the entire cabin, but was most severe at the back of the aircraft. The fasten seat belt sign was not on at the time but was switched on immediately the turbulence started. The crew described the turbulence as a big jolt followed by much shuddering. This lasted for almost a minute, but to the crew it felt longer. The severity was such that several crew at the back of the aircraft were lifted off their feet and half-carts positioned at the crew seats in the area at door 4 were toppled onto their sides.

When the turbulence struck crewmembers were in the following areas:

**Cabin Manager No. 1:** Was located in the Premier cabin collecting trays into meal carts, working in the aisle on the left. She braced herself for a while and then returned to Door 1 and made a P.A. advising passengers to return to their seats and fasten their seat belts.

**Crewmember No. 2:** Had come down from the top galley on an errand for the Cabin Manager and was positioned near the middle of the aft galley. She braced herself against the ovens.

**Crewmember No. 3:** Was located near the entrance to the aft galley, close to the toppling half carts and was struck by them. She grazed her shin.

**Crewmember No. 4:** Had arrived at the back of the aircraft, and steadied herself by holding onto the back of seat 46C and the half-cart nearest to door 4 Left. This cart was the only one of the 4 that did not topple. The other three half-carts fell sideways towards the aft galley scattering the contents from the top of the carts around the floor area between doors 4 Left and 4 Right.

**Crewmember No. 5:** Was located in the aft galley at the water boilers. She was lifted into the air and suffered back strain.

**Crewmember No. 6:** Was located in the aft galley near the trash compactor. He was lifted into the air and thrown against the left hand corner of the galley entrance, injuring his lower back on the left side.

**Crewmember No. 7:** Was located in the cockpit confirming the flight progress with the pilot.

**Crewmember No. 8:** Was located near the entrance to the aft galley at the water boilers and was struck by the toppling half carts.

**Crewmember No. 9:** Was located in the Premier cabin collecting trays into meal carts, working in the aisle on the right. She crouched on the armrest of a seat and held on to the cart. She was assisted by the passenger sitting in seat G and his partner in seat D also assisted in holding the cart on the other aisle.

**Crewmember No. 10:** Was located near the mouth of the aft galley, close to the toppling half carts and was struck by same. He bruised the toe of his left foot.

When the turbulence eased the autopilot and the auto-thrust were re-engaged. No further upsets were encountered, but light "chop" was encountered for approximately fifteen minutes afterwards. The F/O made a call on 123.45 Mhz to advise other aircraft of the turbulence, and also made a report (PIREP) to Gander control. After the encounter and while still airborne the F/O contacted Operations Dublin by SATphone, and was asked to confirm whether any G exceedance had occurred. The crew were able to confirm to Dublin that none had been triggered. About 25 minutes after the incident a British Airways aircraft at FL 380 on the same track, advised that they had only encountered moderate turbulence.

The Cabin Manager advised the Captain that six crewmembers had been thrown about during the turbulence. All who were physically injured used the 6 seats in row 4 to attend to their injuries and to use ice packs on their injuries. The duty free service was operated by crewmembers No. 4 and No. 7. The final service was carried out in both cabins and all crewmembers sat in their crew seats for the landing at JFK.

On arrival in New York, and after clearing customs, a crew bus took the Cabin Manager and 4 injured crewmembers via the hotel to the company doctor's surgery. The sixth crewmember declared that she had received no injury. These crewmembers were back at the hotel by 10.15 hrs. Seven of the crew operated home on EI 108 on 3 January 2006. Crewmembers No. 5, No. 6 and No. 10 positioned home on the same flight so as not to further aggravate their injuries. They had appointments with the company doctor, for the following Thursday morning.

Communication with the passengers was well maintained during and after the turbulence. There were no reported injuries amongst the passengers. The Operator classified the turbulence as "Severe".

## 1.2 Aircraft Information

The Manufacturer stated that Aircraft Maintenance Manual section 05-51-17 covers recommended maintenance actions following excessive flight turbulence. They requested that in the case of severe turbulence the manufacturer should be informed. In some cases during turbulence, limit loads have been locally exceeded and additional inspections may be required. They have published a recent article regarding "Managing Severe Turbulence" in their Safety magazine.

## 1.3 Meteorological Information

### 1.3.1 The Jet Stream

The Jet Stream is a "river" or “tube” of air that flows at high altitudes above the earth. It may be 1 to 3 miles thick. In the northern hemisphere, it has a west-to-east general movement. The main significance of the Jet Stream is that it produces our weather patterns.

Clear Air Turbulence (CAT), is the result of the air that is disrupted around the jet stream. At the inner most part of the jet stream called the core, the velocity may be as high as 250 mph. As one moves away from the core, the velocity drops off so that at the edge it may be only 50 mph. At each point at which two differing velocities rub against each other, eddies form causing the airflow to be disrupted. The variability in the disruption will cause variations in the lift produced by the wings causing the airplane to bounce. Because this happens in a short time span, the effect can be dramatic. In fact, an instantaneous descent of 10 to 20 feet is rarely exceeded. The quantitative grade for turbulence is as follows:

**00 :** Nil turbulence.
**01 :** Light
**02 :** Light to Moderate
**03 :** Moderate
**04 :** Moderate to Severe
**05 :** Severe
**06 :** Extreme

Normally, when severe turbulence is encountered, the Captain makes a report of the incident. Technical personnel then examine the aircraft on arrival at its destination. They would then determine if it should be taken off line for further investigation.

### 1.3.2 Crew Briefing

The Captain of the aircraft is briefed on the en-route weather prior to departure. He is given two forecast charts devised by the World Area Forecast Centre, London. One of these, (**Appendix A**), shows flight levels at which jet stream turbulence might be encountered along with wind speed and direction at those locations. Only moderate or severe turbulence is forecast on this chart. The other, (**Appendix B**), shows the upper wind and temperature for FL 340 over the North Atlantic. However, both charts cover a very wide area whereas a larger scale map for this region might be more appropriate. Turbulence due to convective currents (storms) in which there is a high level of moisture is detectable by airborne weather radar. However, CAT occurs in clear air and cannot be seen on the radar. Although one cannot see CAT visually, a close scrutiny of the weather charts or the forecasted turbulence factor on the flight plan, could usually warn pilots of possible affected areas on the route. In the event of severe turbulence being forecast the flight is normally rerouted around the area. In this particular incident, the Captain said that the clear air turbulence was not indicated on the furnished weather charts for their particular Flight Level.

### 1.3 Flight Recorders

The Digital Flight Data Recorder (DFDR) produces a profile of the vertical load factor resulting from any turbulence encountered. This is a useful tool in determining whether local load limits have been exceeded. In this instance however, the DFDR had not been downloaded by the Operator.

## 2. ANALYSIS

### 2.1 CAT Statistics

There are several notable problems with clear air turbulence:

- It cannot always be foreseen so there is often no warning.
- It is usually felt at its mildest in the flight deck and is generally more severe in the aft section.
- It can occur when no clouds are visible.
- Aircraft radars can't detect it.
- It normally occurs at high altitudes, where cruising aircraft suddenly enter turbulent areas.

Turbulence is the leading cause of in-flight injuries. There are countless reports of occupants who were seriously injured while moving about the passenger cabin when clear air turbulence was encountered. From 1981 through 1997 there were 342 reports of turbulence affecting major air carriers.

- Three passengers died, two of these fatalities were not wearing their seat belt while the sign was on.
- 80 suffered serious injuries, 73 of these passengers were also not wearing their seat belts.

Although the seat belt sign may be off, most airlines now advise passengers to keep their seatbelts fastened at all times when seated. The FAA reported that among non-fatal accidents, in-flight turbulence is the leading cause of injuries to airline passengers and flight attendants. Each year, about 58 air passengers in the United States are injured by turbulence while not wearing their seat belts.

However, in this case, there were no reported injuries to passengers aboard the aircraft. This must reflect well on the general efficiency of the Cabin Manager and her staff in the control of passenger movement throughout the cabin. However, the cabin staff engaged in duties throughout the cabin, were necessarily in the standing position and therefore more likely to be injured.

### 2.2 Jet Stream Forecast Maps

A Jet Stream map for the North Atlantic for the time and date in question is shown at **Appendix C.** The map, presented by the California Regional Weather Server (CRWS) archive, shows clearly the pattern of winds in the upper troposphere, on the 300mb pressure surface (which corresponds roughly to FL 320). This is very roughly the level where winds in the upper atmosphere are typically strongest. At the time of the incident, the influence of the west-east Jet Stream was predominant over a large area of the North Atlantic. The critical areas are where the airspeed contours (Isotachs) are close together indicating high-speed gradients and possible clear air turbulence.

This mass of moving air can extend to a depth of 5,000 to 15,000 ft so that if the aircraft was at 35° West Longitude at 18.00 Z, then there was some chance that it would encounter turbulence at FL 380. However, that said, the atmosphere is a complicated place where generalisations cannot be made.

The above server offers a 6 to 72 hour forecast prior to departure, which would be helpful to pilots on the North Atlantic. A forecast chart such as at **Appendix C** gives at a glance, a much clearer picture of the position of the Jet Stream at the time of flight. Its scale is also more appropriate to the North Atlantic.

Colour printouts of Jet Stream forecast maps are also available from Internet sites hosted by NOAA (the US Meteorological Office) and by Environment Canada.

## 3. CONCLUSIONS

### (a) Findings

1. Five crewmembers were injured following en-route air turbulence at FL 380 on a westbound flight.

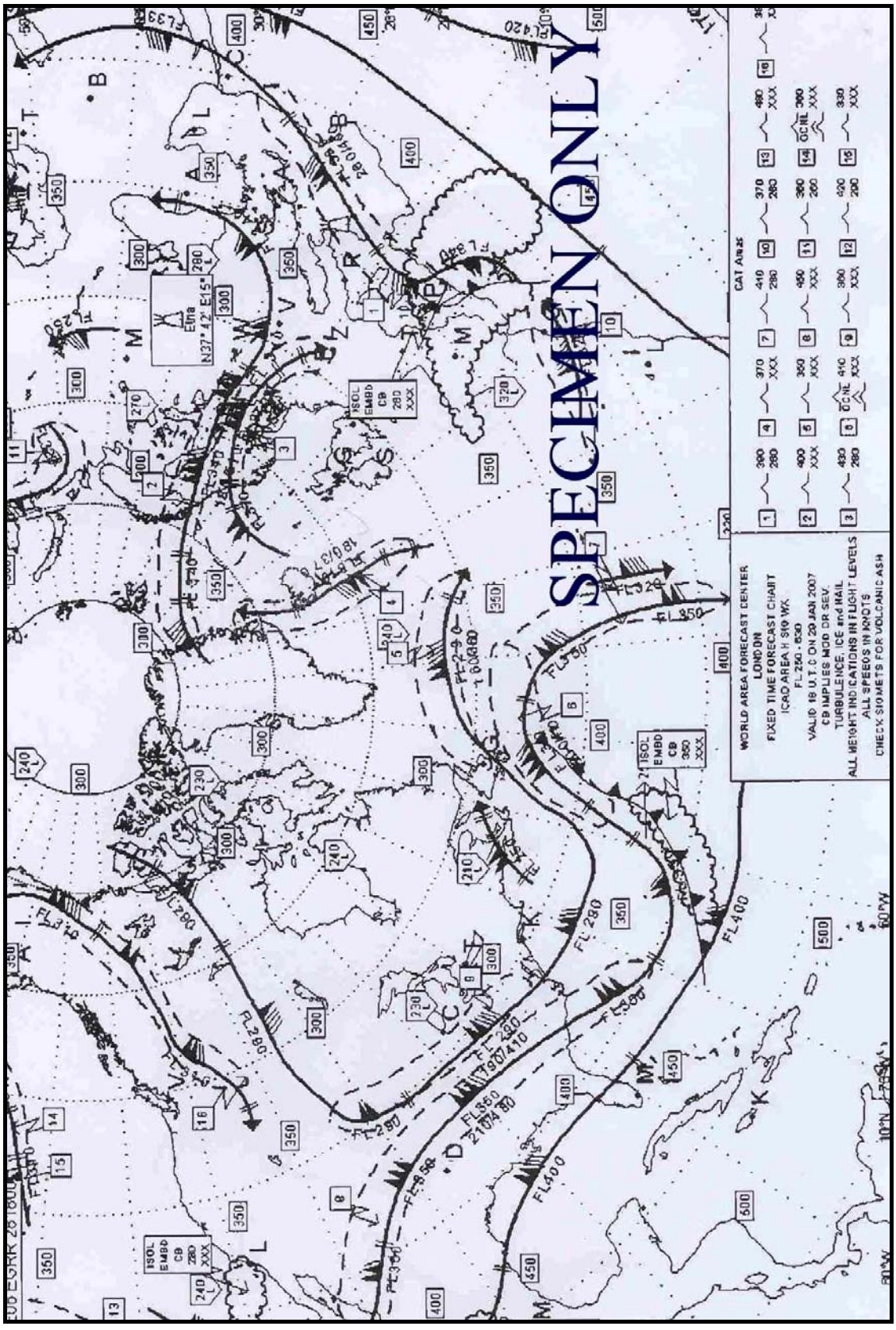
### (b) Cause

1. Without warning the aircraft encountered Clear Air Turbulence (CAT), whilst the crewmembers were working throughout the cabin in standing positions.

## 4. SAFETY RECOMMENDATIONS

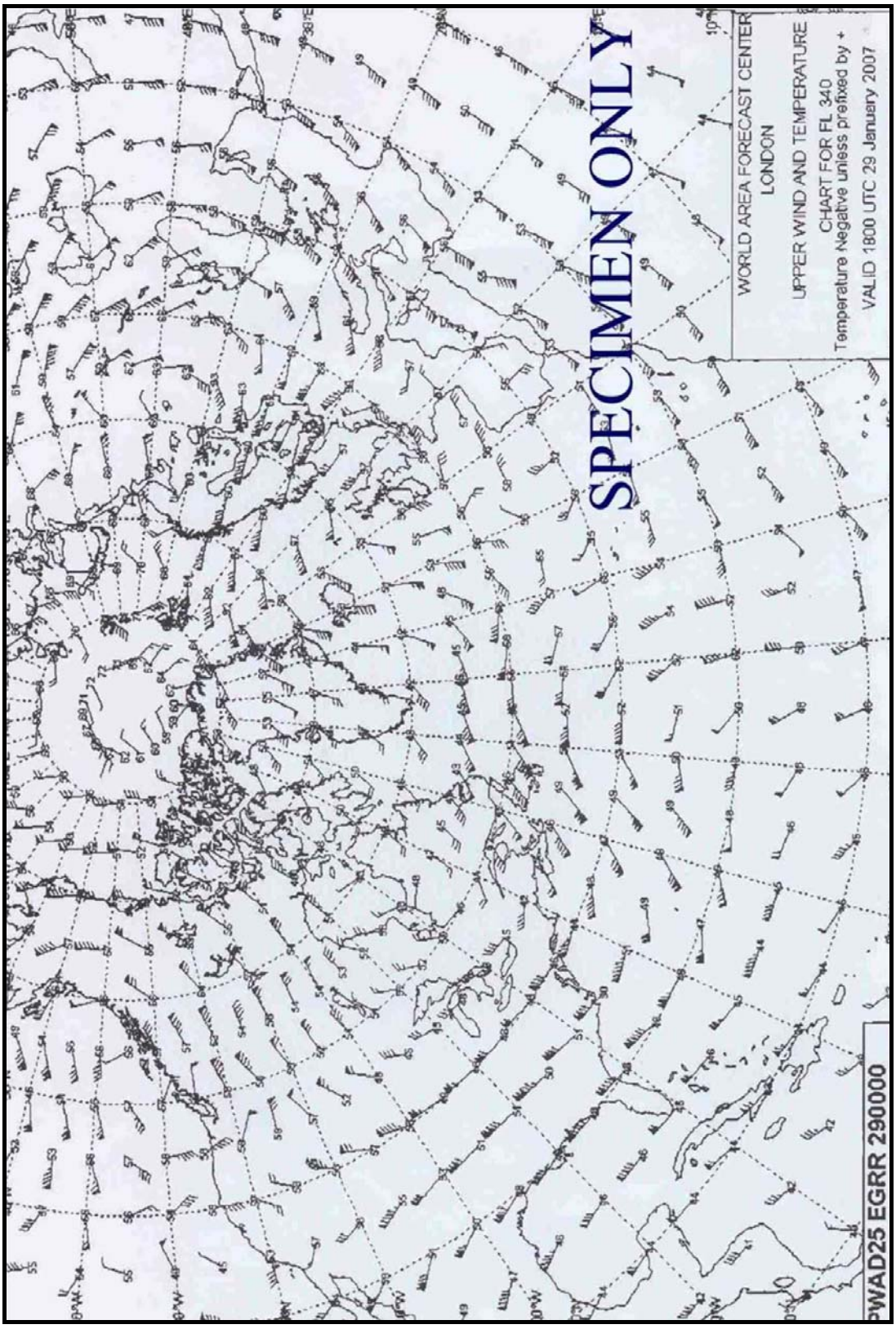
The Operator should consider providing flight crews with a Fixed Time Forecast Chart for the flight whose scale would be more appropriate to the North Atlantic area. **(SR 14 of 2007)**

## APPENDIX A



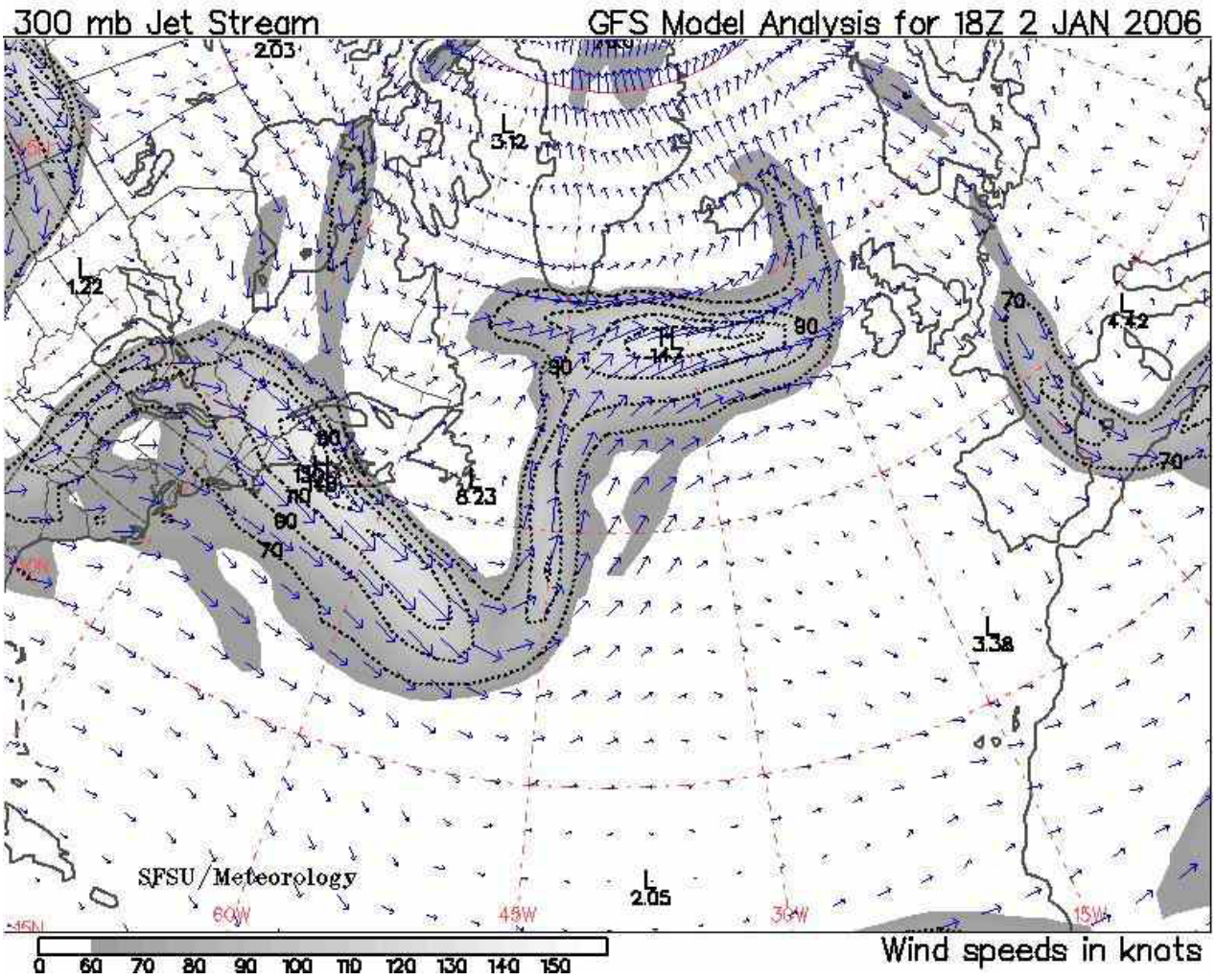

**World Area Forecast Center - Fixed Time Forecast Chart**

## APPENDIX B




**World Area Forecast Center - Upper wind and temperature Chart for FL 340**

## APPENDIX C




A Jet Stream Map from the archives of the Californian Regional Weather Server (CRWS) for the date and time of this incident. Contours of wind speed (Isotachs) are colour-filled in shades of grey, at intervals of 10 knots, starting at 60 knots. Superimposed on these colour-filled contours are black, labelled, dashed-line contours at intervals of 20 knots, starting at 70 knots. Local maximum wind speeds ("jet streaks") are marked with "H" and labelled with the wind speed there. The blue arrows represent the direction and speed of the wind. Longer arrows represent faster winds.