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EXAMPLES OF THE ADVANTAGES OF ACARS DATA

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[*Note: All figures appear only in the web version of the Technical Attachment.*]

Introduction

ACARS is the term used by the NOAA Forecast Systems Laboratory (FSL - http://www.fsl.noaa.gov/) to designate automated weather reports from commercial aircraft. These data are routed by cooperating airlines to FSL, where the data are decoded and quality controlled. More generally, **ACARS** stands for the **A**ircraft **C**ommunications **A**ddressing and **R**eporting **S**ystem, managed by Aeronautical Radio, Inc. (ARINC - http://www.arinc.com/). ACARS is used by airlines to transmit a variety of proprietary air-to-ground communications. An overview of ACARS data are available from FSL at http://acweb.fls.noaa.gov/FAQ.html.

Current participating airlines include United, American, Delta, Northwest, Federal Express, and United Parcel Service (UPS). Most ACARS-equipped aircraft provide latitude, longitude, altitude, time, temperature, wind direction, and wind speed. Some aircraft also provide turbulence data in the form of either vertical acceleration or eddy dissipation rate. A small subset of aircraft, mostly UPS, also provide moisture data. Data quality is comparable to other upper-air data sources as indicated in the papers of Lord, et al. (1984) and Schwartz and Benjamin (1995). Vertical resolution of the data varies by airline. For example, vertical resolution of data from United is usually 2000 feet. Some carriers provide data every few hundred feet at lower levels. These differences in vertical resolution are critical for some applications. Data are available mostly from newer, larger aircraft, though a few commuter aircraft are also ACARS-equipped. The impact on data availability is that data is most frequent from airports with jet service from the participating air carriers.

While there are restrictions on the use and access of ACARS data by informal agreement between FSL and the participating airlines, the data are available for use by NWS forecasters. Data may be accessed from FSL's Aircraft Data Web at http://acweb.fsl.noaa.gov/. NWS offices seeking access to real-time ACARS data should contact Bill Moninger, moninger@fsl.noaa.gov, at FSL at 303-497-6435.

Sources of ACARS Data

FSL's Aircraft Data Web:	http://acweb.fsl.noaa.gov/
FSL's Full ACARS Display (java):	http://acweb.fsl.noaa.gov/java/
FSL's ACARS Display (non-java):	http://acweb.fsl.noaa.gov/oper/

Access to FSL's worldwide sounding database, including ACARS soundings:
http://www-frd.fsl.noaa.gov/mab/soundings/java/

Uses of ACARS Data

Forecast applications of ACARS data in southern California:

- Determination of the height and strength of the coastal marine inversion - useful for forecasting of coastal stratus
- Monitoring changes of the freezing (snow) level during winter storms
- Updating environmental data for the WSR-88D hail algorithm
- Monitoring the strength and depth of winds aloft for wind events, particularly downslope wind events such as sundowners (Ryan, 1996) and Santa Ana's (Small, 1995)
- Monitoring the strength and height of inversions critical to mountain wave development

During the recently concluded national evaluation of ACARS data, additional applications by other offices included the following:

- Monitoring of changes in vertical temperature profiles with applications to precipitation-type forecasts
- Forecasts of mixing heights for fire weather forecasts
- Monitoring changes in stability and low-level vertical wind shear with applications to convective forecasts (Mamrosh, 1998) and storm-type forecasts
- Monitoring of winds aloft by CWSU's to maintain a smooth flow of air traffic into major air traffic hubs, avoiding problems associated with "compression" of air traffic into hubs
- Assessing model performance, primarily when displaying data in plan view mode

In addition to the local forecast applications highlighted above, ACARS data are routinely ingested into NCEP models. For daily examples of how ACARS data are used in local forecast and warning applications, a log of all forecast discussions referring to "ACARS" or "aircraft" data is maintained at http://acweb.fsl.noaa.gov/docs/fcst-disc/.

Advantages of ACARS Data

ACARS data have the advantage of providing greater spatial and temporal sounding detail in the vicinity of areas with significant commercial air traffic and at times of day when such flights are greatest. Such data can be a useful **supplement** to upper-air data from the more widely spaced and less frequently available raob soundings.

Limitations of ACARS Data

The major limitations of ACARS soundings relative to raobs is the lack of moisture data and spatial and temporal limitations on availability. Few ACARS-equipped aircraft contain moisture sensor instrumentation, hence availability of moisture data is very limited. However, the moisture data that is available is of high quality. Because few commuter aircraft are yet ACARS-equipped and because service of ACARS-equipped aircraft from the participating carriers is limited mostly to major airports (where frequency is greatest on weekdays and during the daylight and early evening hours), there are limitations on the spatial and temporal availability of the data.

A secondary limitation of ACARS data, dependent upon the participating carrier, are differences in the vertical resolution of the data. Vertical resolution of the data in the lowest several thousand feet of the atmosphere ranges from a few hundred feet to 2000 feet or so depending on the carrier. Depending upon the intended use of the data, such differences may be critical. A primary example in southern California of the importance of adequate vertical resolution has been in monitoring the height and strength of the coastal marine inversion. Those soundings with a vertical resolution of a few hundred feet in the lower levels of the atmosphere are of great value. Conversely, those soundings with a vertical resolution of 2000 feet are often of little use for this application.

Example 1 - Santa Ana Winds

Figure 1 is a sounding from a flight into Ontario, CA (ONT) during a moderate Santa Ana wind event. Figure 2 contains the descent track into Ontario for that flight and for a second flight descending on a similar track at about the same time. Both flights arrived into Ontario at similar times, with similar descent tracks from the southeast, similar low-level vertical resolution of the data, and similar low-level wind and temperature profiles. Evident in the sounding in Fig. 1 are a low-level east-northeasterly jet below Banning Pass to the east of Ontario, and a northeasterly jet below Cajon Pass to the northeast of Ontario. Such spatial resolution of flow associated with Santa Ana winds has not previously been available from other upper-air data sources.

Example 2 - Monsoonal Moisture

Raobs from Desert Rock, NV (DRA), Yuma, AZ (YUM) (both not shown), and Miramar Naval Air Station, CA (NKX) (Fig. 3) for 1200 UTC on 4 August 1999 all showed mid-level moisture and associated southeasterly flow. The moisture and southeasterly flow were greatest and deepest at DRA and YUM. Raobs from VBG, NKX, and DRA (all not shown) for 0000 UTC on 5 August 1999 showed that the mid-level moisture did not extend as far northwest as Vandenberg Air Force Base, CA (VBG) with dry west-southwesterly flow at all levels above the marine inversion at VBG. The 0000 UTC sounding from NKX (Fig. 4) on 5 August 1999 showed that drying of the mid-level moisture had occurred since the 1200 UTC sounding with west-southwesterly flow at all levels above the marine inversion. Little change in the mid-level moisture and flow was noted in the sounding for DRA (not shown) for 0000 UTC on 5 August 1999 compared to the earlier 1200 UTC sounding on 4 August 1999.

One forecast concern was the westward extent of moisture that enhanced development of an isolated severe thunderstorm over central Imperial County in the deserts of southeastern California early on the evening of 4 August 1999. ACARS soundings with moisture data just happened to be available early that evening from Los Angeles (LAX) (Fig. 5) and San Diego (SAN) (not shown) around 0230 UTC on 5 August 1999, and from ONT around 0430 UTC (Fig. 6) and 0630 UTC (Fig. 7) on 5 August 1999. Figure 8 contains a map of the flight tracks for these ACARS soundings with moisture data. This map also contains an overview of sounding and airport locations in the vicinity of southern California.

The ACARS soundings from LAX and SAN showed west-southwesterly flow at all levels above the marine inversion. Mid-levels in the sounding from LAX were dry with only a minor amount of mid-level moisture evident in the sounding from SAN, similar to the raob from NKX. The soundings from ONT showed mid-level moisture centered around 600 mb and associated south-southeasterly flow with a drying trend noted between 0430 UTC and 0630 UTC on 5 August 1999. Based on the persistence and strength of the west-southwesterly flow for the coastal sites and the slow drying trend noted in the soundings from ONT, one could infer that the western edge of the mid-level moisture would not move farther west and in fact would likely begin to move back to the east. Later ACARS soundings with moisture from ONT around 0900 UTC on 5 August 1999 (Fig. 9) confirmed this expected drying trend with substantial drying at mid-levels from earlier soundings and a shift of the mid-level winds from southeasterly to west-southwesterly.

Raobs from DRA and YUM (not shown) for 1200 UTC on 5 August 1999 showed little change in the mid-level moisture and associated southeasterly flow from the soundings the 24 hours previous. In contrast, the sounding for NKX (not shown) showed drying at mid-levels with a shift in the mid-level flow from southeasterly to weak southwesterly.

Example 3 - Coastal Marine Inversion

ACARS soundings with sufficient vertical resolution have been quite useful in monitoring trends in the height and strength of the marine inversion (Martin, 1999). This has allowed for greater precision in forecasts of the areal extent of coastal stratus and in forecasts of the height of the bases and tops of the stratus. ACARS soundings in southern California on the 4 and 5 August 1999 highlight the advantages of using ACARS soundings to evaluate the marine inversion versus relying only on raobs from VBG and NKX.

Soundings from VBG (not shown) and NKX (Fig. 4) on 0000 UTC on 5 August 1999 showed the base of a strong marine inversion near 1500 feet mean sea level (MSL). ACARS soundings from LAX (Fig. 5), Long Beach, CA (LGB) (not shown), and John Wayne Airport, CA (SNA) (not shown) around 0230 UTC on 5 August 1999 all showed the base of a strong marine inversion at around 1000 feet MSL, lower than that shown in the closest raobs. The availability of ACARS soundings was useful in showing spatial variations in the coastal marine layer and in highlighting the potential for cloud bases in coastal sections of the Los Angeles Basin to initially be below 1000 feet MSL. Relying solely on the raobs from VBG and NKX, one would have expected cloud bases between 1000 and 1500 feet. The availability of ACARS soundings allowed for greater precision in cloud height forecasts in Terminal Aerodrome Forecasts (TAF's) for LAX, LGB, and SNA than would likely have occurred with the absence of these soundings. A sounding from ONT a little later, around 0430 UTC on 5 August 1999 (Fig. 6), showed the base of the marine inversion near 1700 feet MSL, marginally deep enough for coastal stratus to be able to spread into the inland valleys east of Los Angeles overnight. Soundings from ONT around 0900 UTC on 5 August 1999 (Fig. 9) showed that the base of the marine inversion had changed little, remaining near 1700 feet MSL.

The raob from NKX for 1200 UTC on 5 August 1999 (Fig. 10) showed the base of the marine inversion had deepened to around 2000 feet MSL. ACARS soundings from LAX at 1200 UTC on 5 August 1999 (Fig. 11) and ONT at 1300 UTC on 5 August 1999 (Fig. 12) showed similar deepening to around 2000 feet MSL. The availability of ACARS soundings allowed for greater precision in monitoring spatial and temporal trends in the coastal marine inversion than would have been possible by relying solely on available raobs.

Conclusions

At present, the utility of ACARS data is dependent upon the intended use of the data and and the temporal and spatial availability of the data. Hence, the greatest value of the data is often for those sites with a larger number of potential applications of the data and in areas with airports with larger numbers of flights of ACARS-equipped aircraft.

However, when ACARS data are displayed in plan view mode for purposes of assessing the quality of model initial analyses and assessing model performance, even sites far removed from commercial aircraft hubs should be able to find value from this additional upper-air data source.

Acknowledgments

Thanks to Bill Moninger at FSL for his continuing efforts to improve the accessibility and display capabilities for viewing ACARS data. Thanks to David Danielson and Todd Morris at NWSFO Los Angeles/Oxnard and Rick Decker at the National Weather Service Office of Meteorology for supporting ACARS evaluation efforts in southern California. Thanks also to forecasters at NWSFO Los Angeles/Oxnard and NWSO San Diego whose input during the evaluation process has led to improvements in the access and display of ACARS data and in turn increased the utility of such data in the forecast and warning process.

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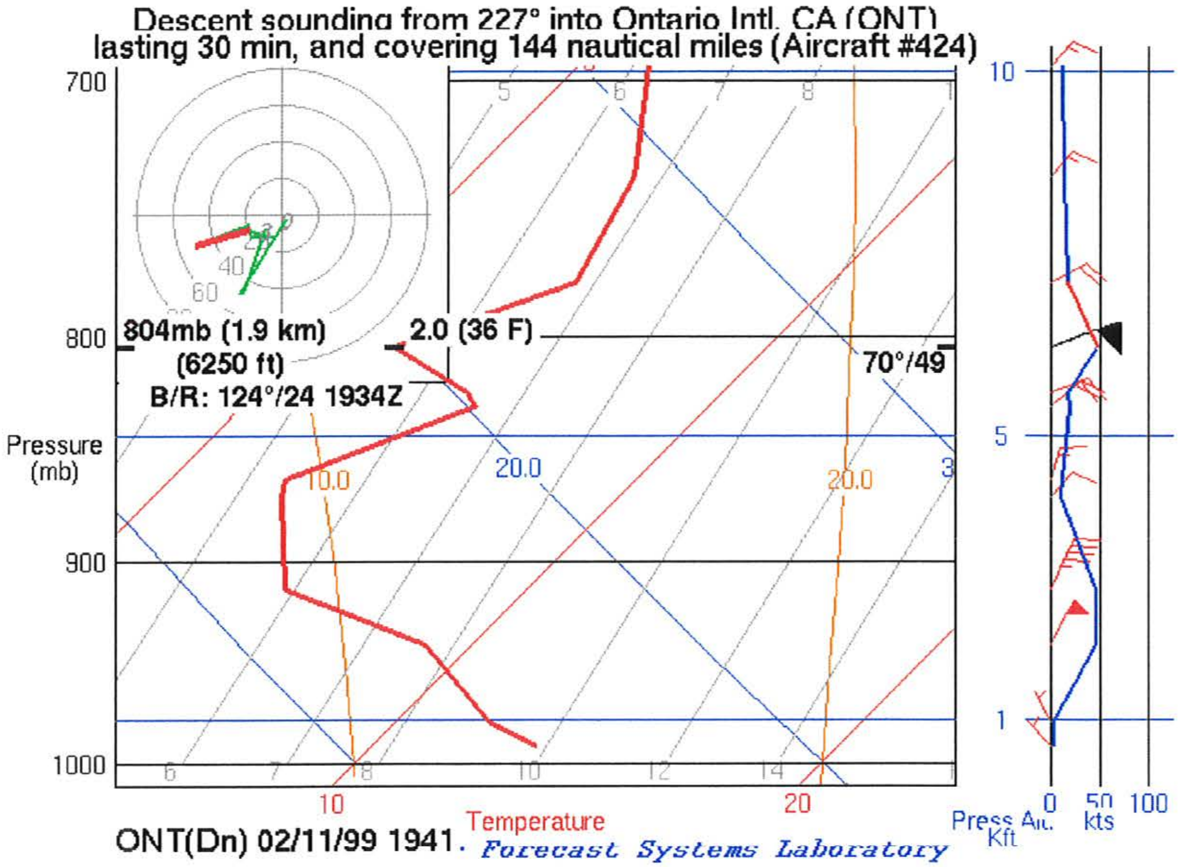

Figure 1. Descent sounding into Ontario, CA (ONT) arriving at 1941 UTC on 11 February 1999

Flight tracks into Ontario near 1940 UTC on 11 February 1999

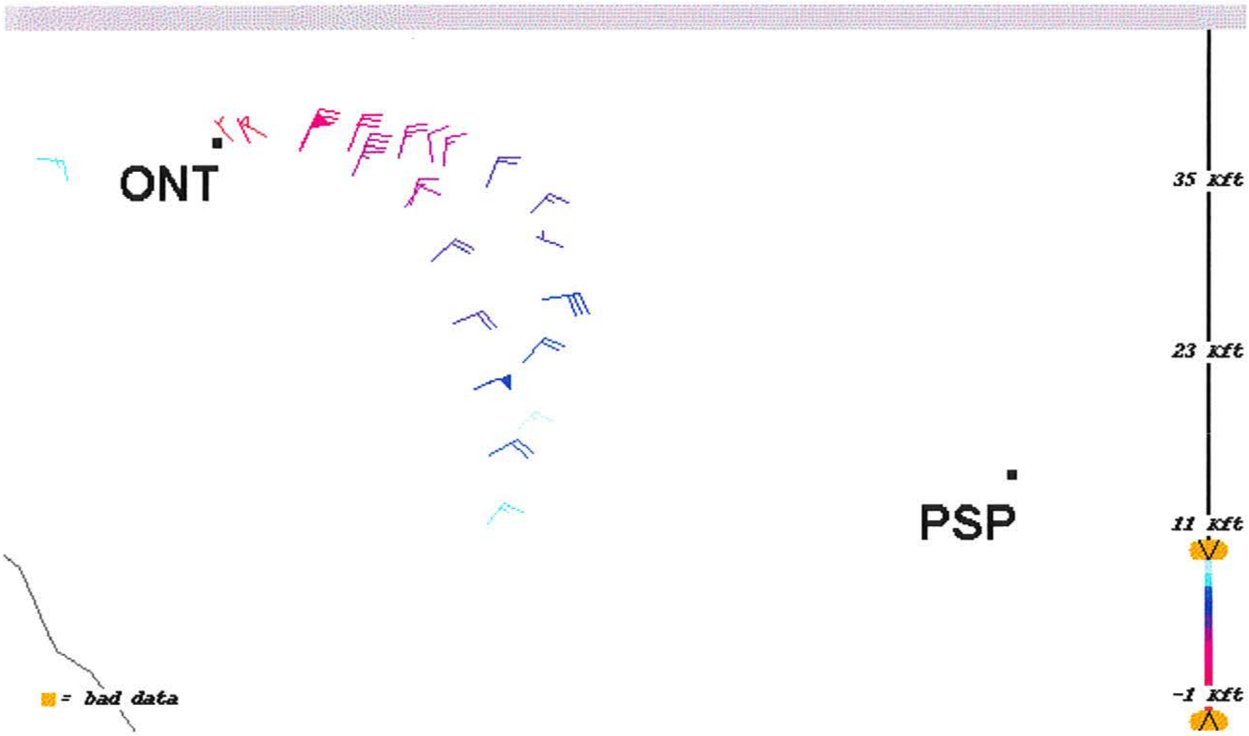

Figure 2. Descent flight tracks into Ontario, CA (ONT) arriving near 1940 UTC on 11 February 1999

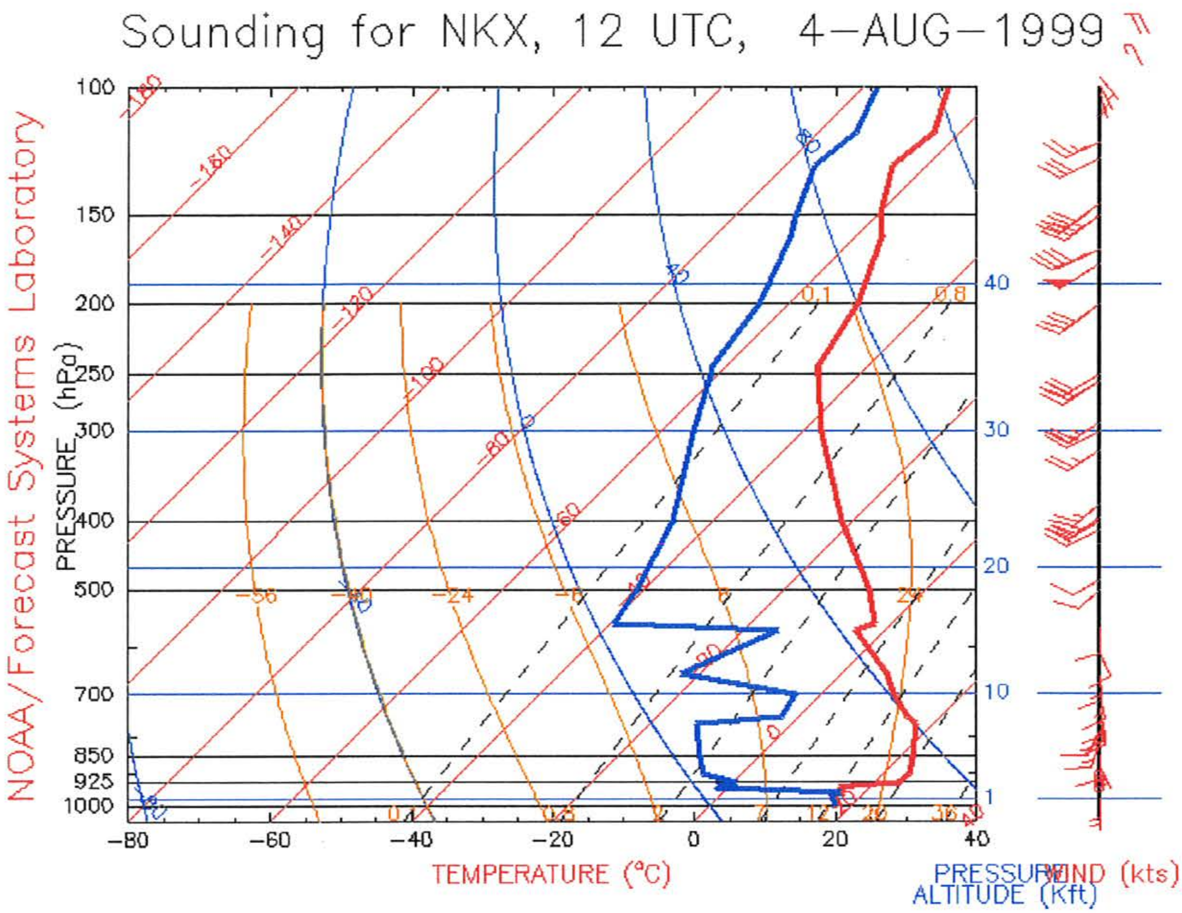

Figure 3. Raob for Miramar NAS (NKX) for 1200 UTC on 4 August 1999

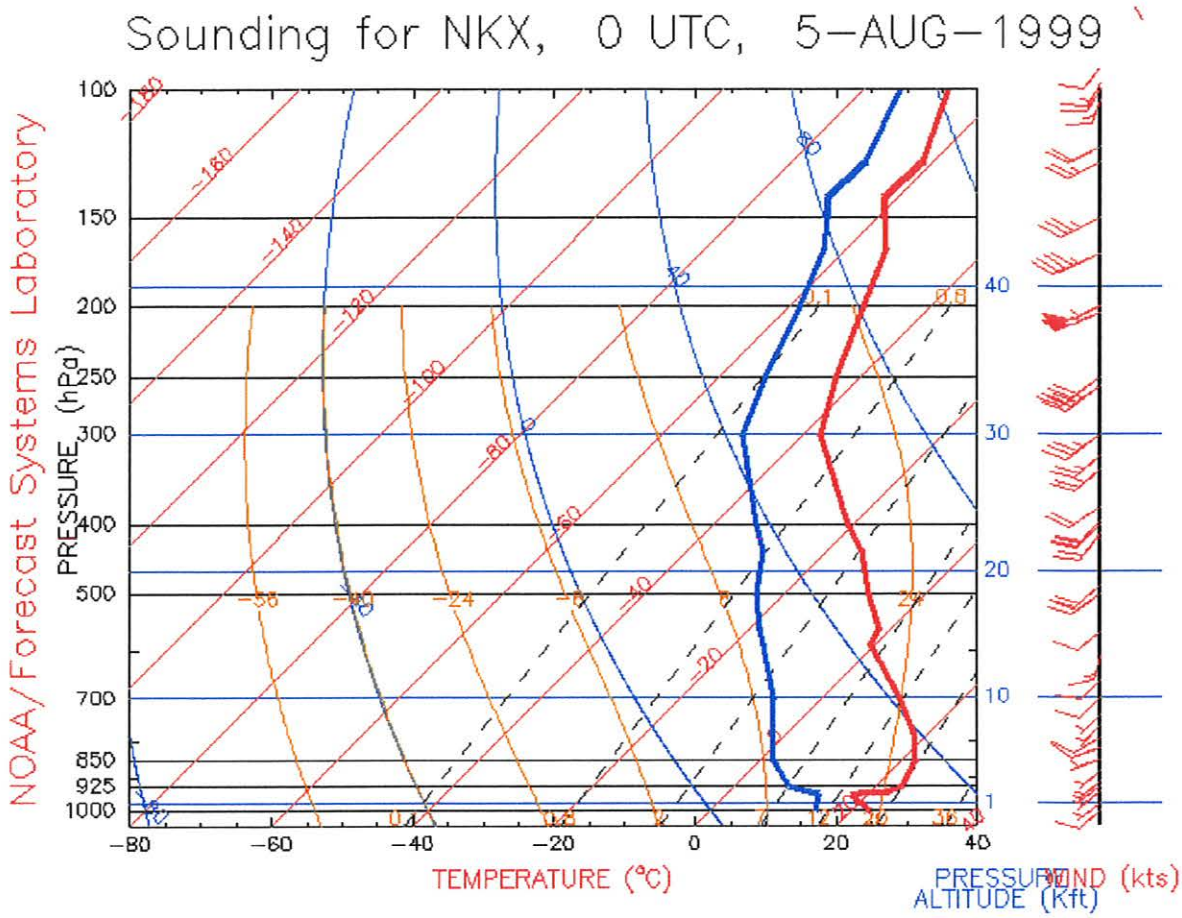

Figure 4. Raob for Miramar NAS (NKX) for 0000 UTC on 5 August 1999

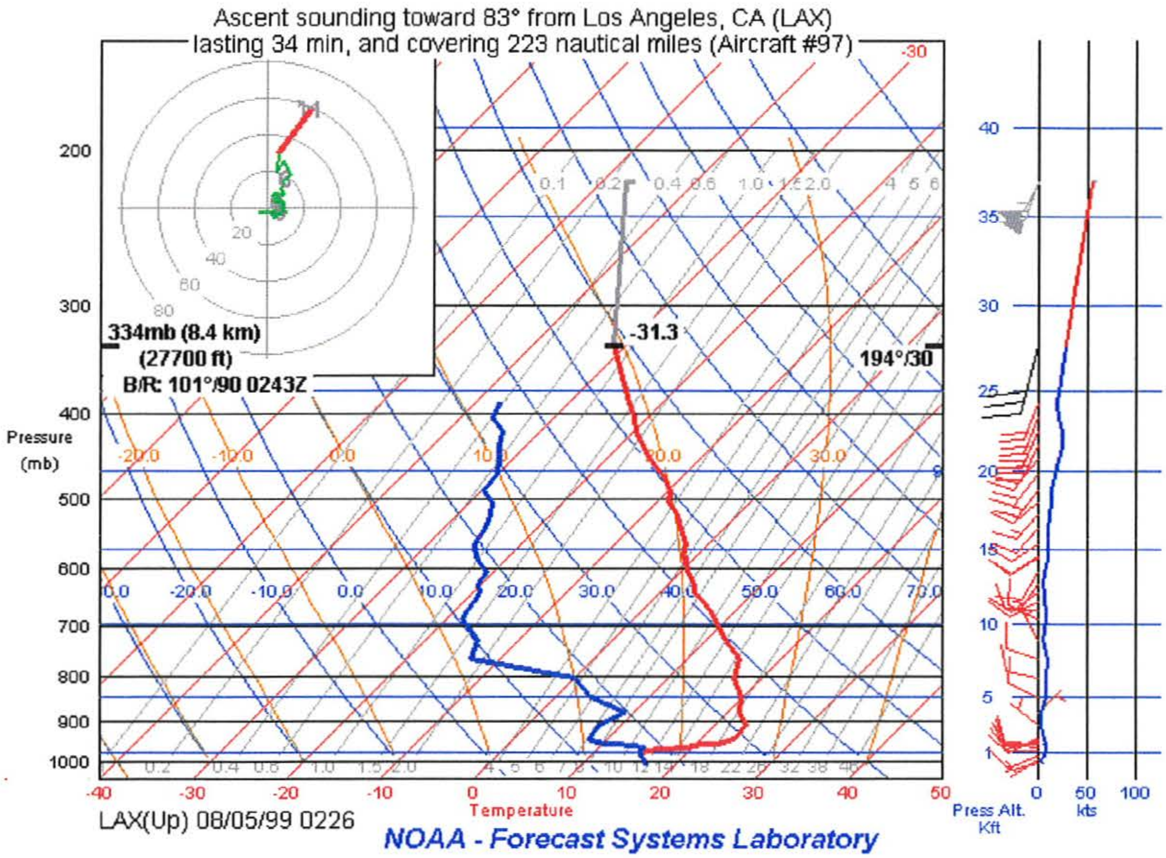

Figure 5. Ascent sounding departing from Los Angeles International Airport (LAX) at 0226 UTC on 5 August 1999

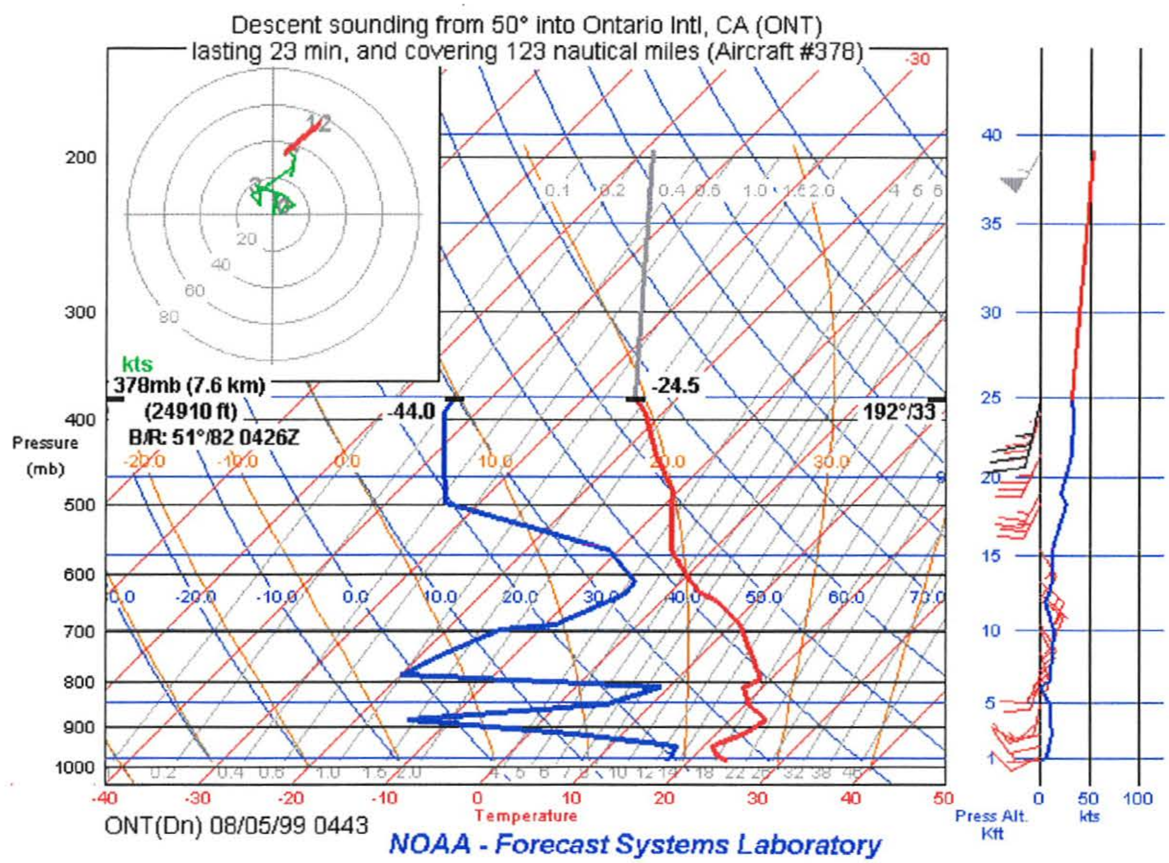

Figure 6. Descent sounding into Ontario, CA (ONT) arriving at 0443 UTC on 5 August 1999

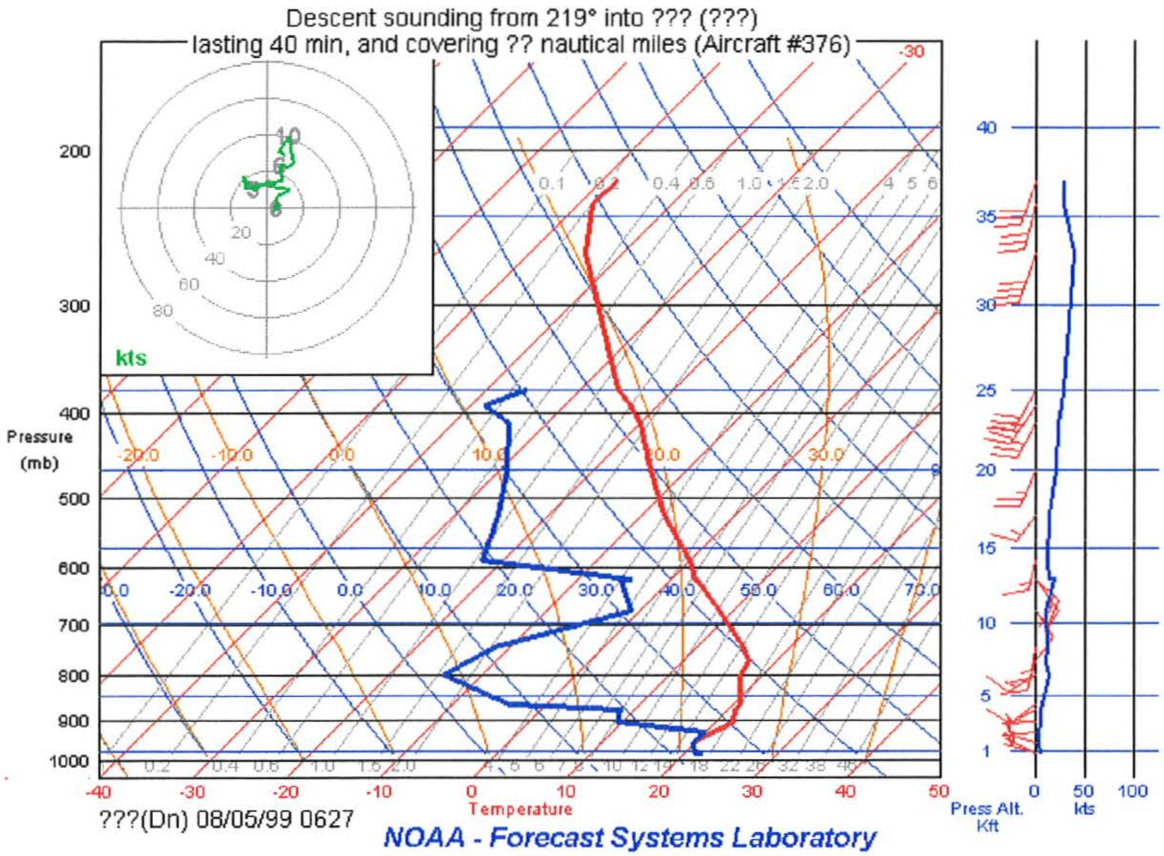

Figure 7. Descent sounding into Ontario, CA (ONT) arriving at 0627 UTC on 5 August 1999

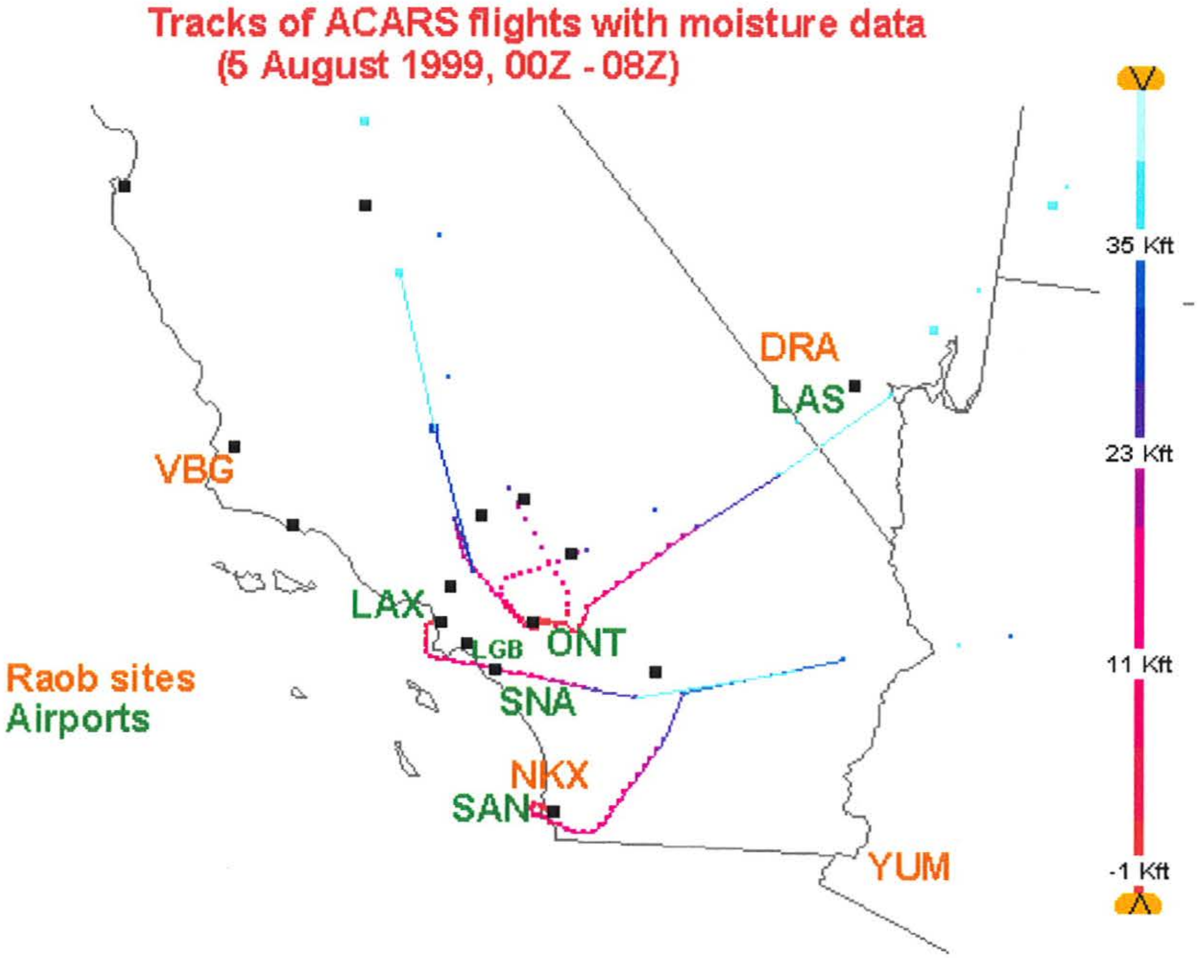

Figure 8. Tracks of ACARS flights with moisture data into Southern California on 5 August 1999

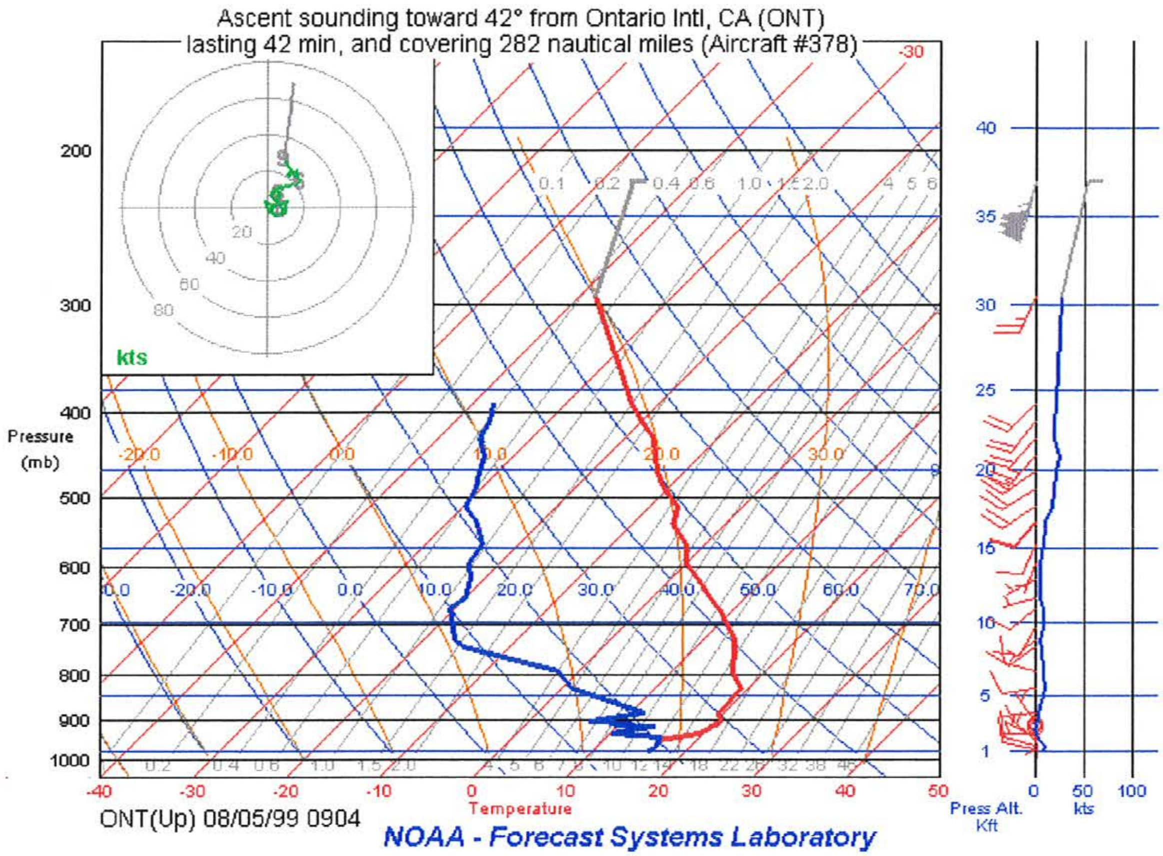

Figure 9. Ascent sounding departing from Ontario, CA (ONT) at 0904 UTC on 5 August 1999

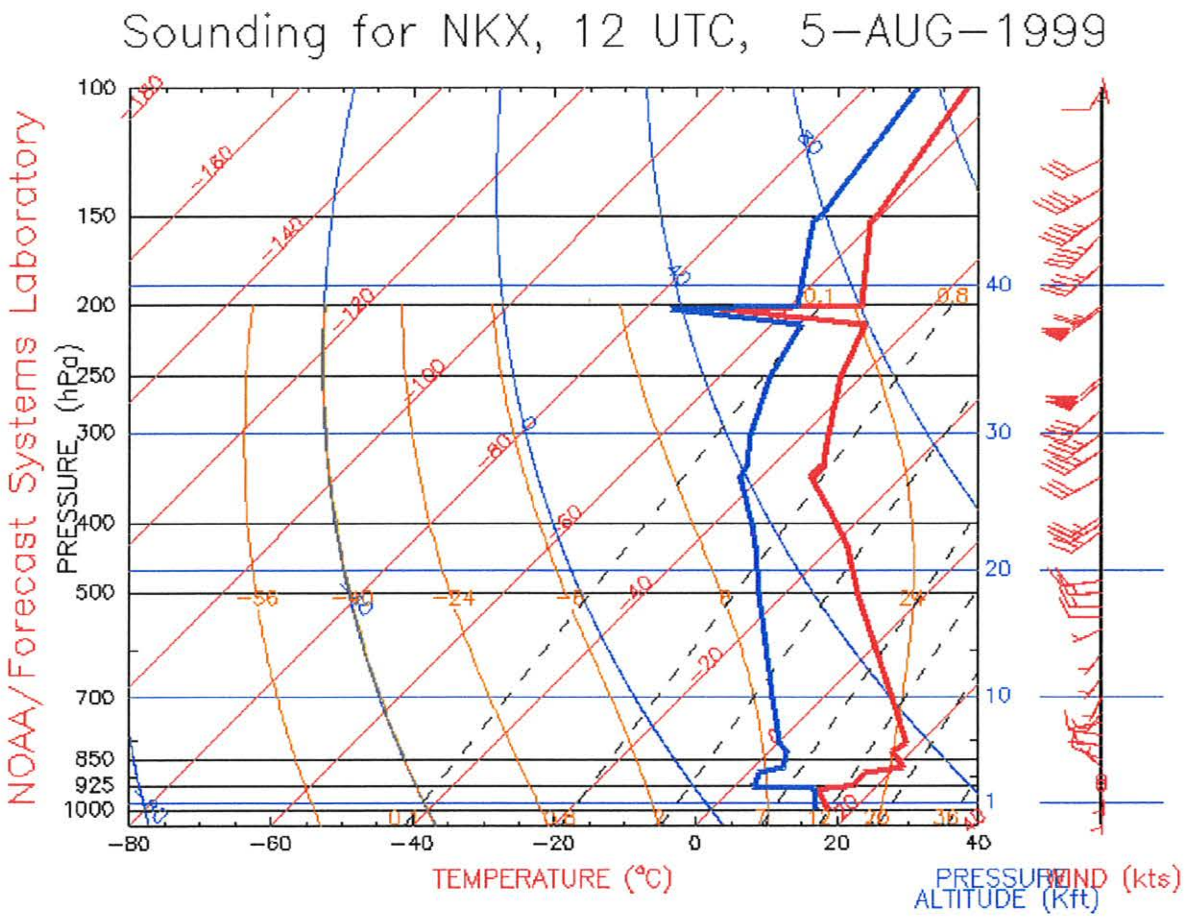

Figure 10. Raob from Miramar NAS (NKX) for 1200 UTC on 5 August 1999

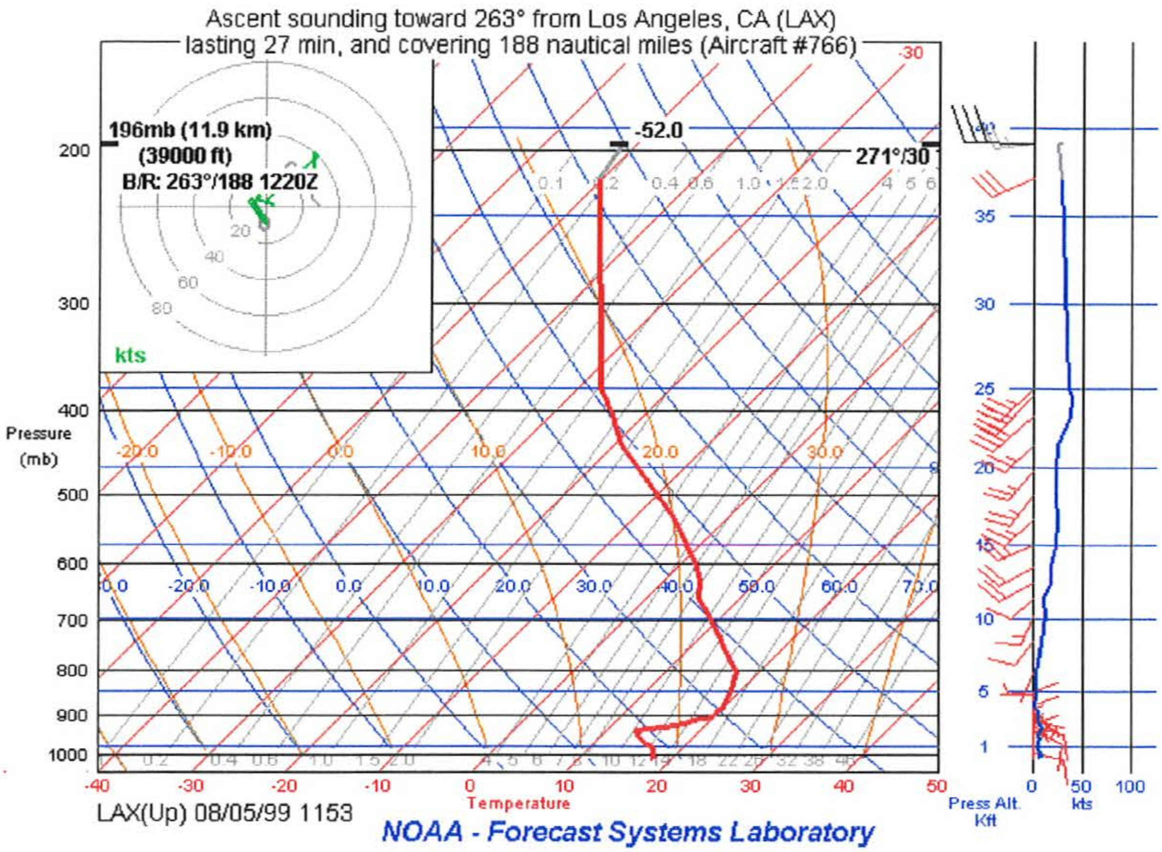

Figure 11. Ascent sounding departing from Los Angeles International Airport (LAX) at 1153 UTC on 5 August 1999

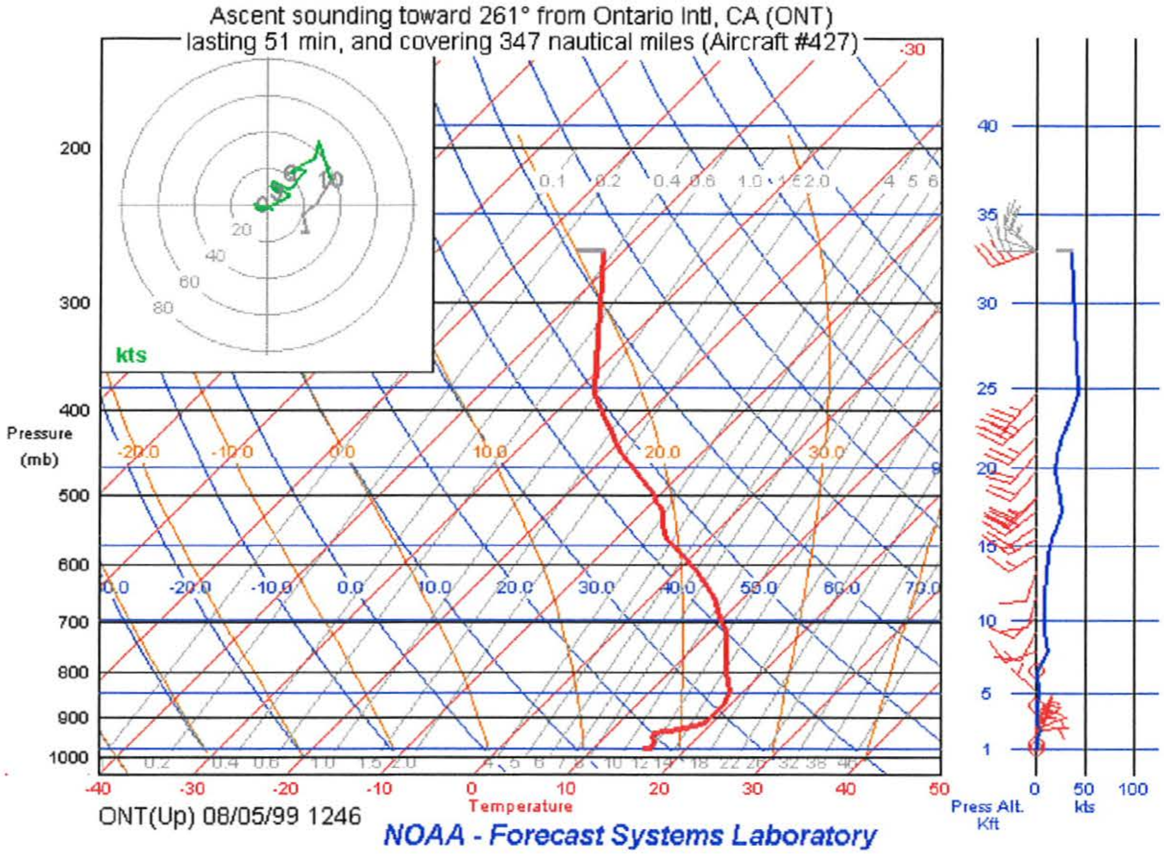

Figure 12. Ascent sounding departing from Ontario, CA (ONT) at 1246 UTC on 5 August 1999