The Front

July 2003 National Weather Service Volume 2, Number 2

Aircraft Weather Observations Improve Forecasts

By Richard Mamrosh, Forecaster
NWS, Green Bay, WI

In addition to providing fast and safe transportation, many commercial jet aircraft report weather data that is helping the National Weather Service (NWS) produce better forecasts and warnings.

Automated weather reports from these aircraft have contributed to a significant improvement in forecast accuracy over the past 10 years. These wind and temperature reports are automatically transmitted from selected aircraft of six major airlines, and have lead to improvements in aviation, public and marine weather forecasts.

American, Delta, Federal Express, Northwest, United, and United Parcel Service have agreements permitting the NWS and the Federal Aviation Administration use of this data in NWS warning and forecast services.

An average of more than 150,000 reports are available daily, and supplement upper air data from pilot reports (PIREPS), weather balloons and satellites. The information flows to the National Center for Environmental Prediction, where it is ingested by NWS computer models. The data also goes to the Forecast Systems Laboratory, where it is displayed on an interactive Web page. See Figure 1, below.

While most aircraft only report temperature and wind, an increasing number of aircraft also report turbulence and icing. Humidity sensors were installed on a few dozen aircraft in the late 1990s as part of an experi-

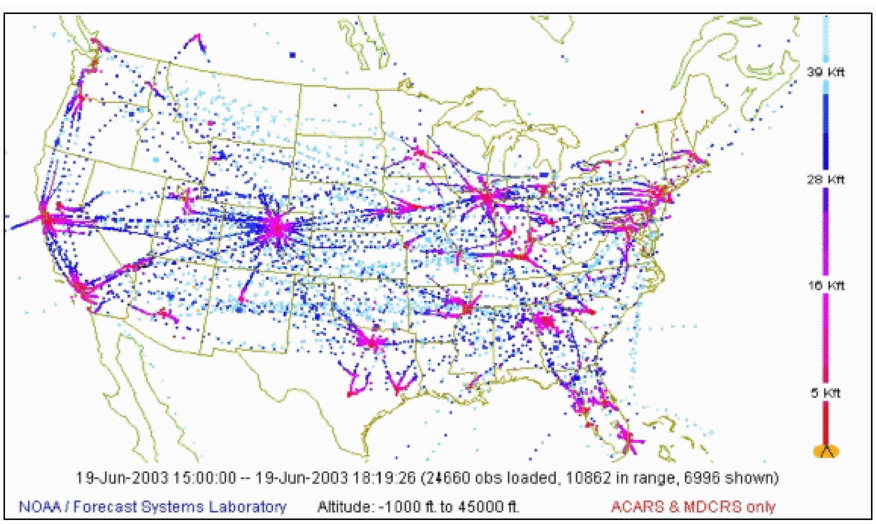

Figure 1: *Example of data for three hour period on July 19, 2003*

In this Issue:

The Front

Managing Editor: Michael Graf
Contributing Editor: Craig Sanders
Editor: Melody.Magnus@noaa.gov

Mission Statement

To enhance aviation safety by increasing the pilot's knowledge of weather systems and processes and National Weather Service products and services.

__Figure 2:__ Navy bi-plane with meteorograph on starboard wing strut taking meteorological measurements of pressure, temperature, and humidity.

ment that will be expanded later this year. Humidity is highly variable in the atmosphere and difficult to measure; however it is vital to accurate forecasts of precipitation and icing.

Brief History: Aircraft Weather Data

In 1919, The NWS began paying pilots to fly piston engine aircraft with weather instruments strapped on the wings of their biplanes. NWS paid pilots only if they reached an altitude of more than 13,500 feet; pilots received a bonus for every thousand feet thereafter. The lack of pressurized aircraft, navigational aids or aviation weather forecasts made the task extremely dangerous.

These flights were discontinued in 1940 with the advent of radiosondes, weather instruments carried aloft by balloons. PIREPS continued to supply important weather reports of conditions above the ground. In the 1960s, these reports appeared in numerical weather prediction models. By the 1980s, datalink systems allowed meteorological data to be retrieved automatically from an increasing number of aircraft. Currently, about 1,500 commercial aircraft transmit weather information. This number is likely to increase further as regional, corporate, and some general aviation aircraft install datalink systems.

Importance and Future of Aircraft Weather Reports

This automated data, Aircraft Communications Addressing and Reporting System (ACARS) or Meteorological Data Collection and Reporting System (MDCRS), has been used as input to the numerical weather prediction models for the past 10 years. In one of the models, aircraft wind data was found to be even more important than radiosondes. When air travel was halted for several days after September 11, 2001, the chief short-range NWS computer model showed a dramatic reduction in forecast skill.

The data is used by NWS and airline meteorologists to forecast aviation hazards such as turbulence, icing, fog and low level wind shear. This data is also used to forecast high wind events, snow and ice storms, severe thunderstorms, and other phenomena. NWS Center Weather Service meteorologists at Air Route Traffic Control Centers routinely use ACARS to locate jet streams that cause dangerous turbulence.

Lyle Alexander, meteorologist at the Indianapolis CWSU says, "We had some turbulence in the area, and the ACARS data helped me to mark off the areas where the turbulence was occurring. The models gave me an idea where it might be, but the ACARS helped me to fine tune it, resulting in a more accurate forecast."

Mike Foley, a dispatcher with Delta Airlines adds, "I use ACARS data to provide real time turbulence information to our flight crews. Used in conjunction with real time PIREPS, it generally makes the cause and location of the turbulence much easier to find."

Figure 3 shows the tremendous amount of real-time wind data available to NWS, airline and FAA meteorologists for a typical 3-hour period on an average day.

The data on this day shows an upper level low near Cleveland and winds of 50 to 100 knots on either side of the upper low.

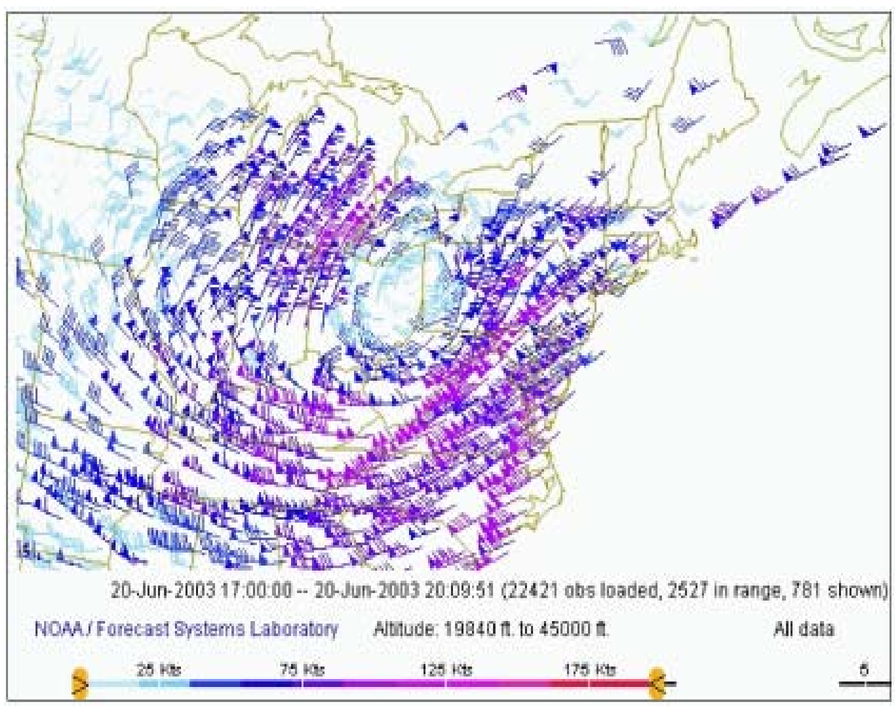

__Figure 3:__ Example of winds from approx. 20,000 to 45,000 feet MSL for the three hour period ending 2000 UTC June 20, 2003

Weather data from aircraft will become even more important in the future as meteorologists attempt to make forecasts with greater accuracy and detail. Radiosondes are routinely launched twice a day in the morning and evenings, and are roughly 200 miles apart. This schedule is often not sufficient to resolve weather phenomenon such as thunderstorms, icing and turbulence.

Experiments are now being conducted to determine whether it is cost effective to install weather instruments and datalink systems on regional, corporate and general aviation aircraft.

One such experiment called Tropospheric Airborne Meteorological Data Report (TAMDAR) is a joint NASA/FAA/NWS project to be conducted later this year. The idea is to install relatively inexpensive sensors that will measure temperature, humidity, wind, turbulence and icing on turboprop aircraft for a regional airline. If successful, similar sensors could be used on corporate and general aviation aircraft.

Current Data Access

Due to proprietary considerations, basic aircraft weather data is available only to the participating airlines, the FAA, and NWS. Airlines have historically borne some of the costs associated with transmitting the data. You can still benefit from this data source by accessing a numerical model called the Rapid Update Cycle at **http://ruc. fsl.noaa.gov**.

The model is run every 3 hours with the latest data and upper level winds, pressure patterns, and forecast vertical soundings of the atmosphere can be displayed at many U.S. airports.

Accurate aviation forecasts require in-flight data from both light single engine aircraft and jumbo jets! Automated aircraft weather data and PIREPs can be combined to give the meteorologist the information for making make detailed and accurate forecasts of aviation hazardous. ✈

Enhance PIREPs By Getting More from Your GPS

By Craig Sanders
Lead Forecaster, NWS Duluth

Some commercial aircraft send pilot reports (PIREPs) through the ACARS data link. They can send any combination of computed wind speed, temperature, turbulence, and humidity for input into the NWS Rapid Update Cycle (RUC) computer model. Getting a little black box like that for your GA or corporate aircraft requires a bit more than pocket change.

The good news is that you don't need that particular technology to serve your fellow pilots well. You can be of great service with the GPS box that's already there. Most GPS boxes enable you to set up flight plans, routes, approaches and holds, as well as monitor ground speed, time en route, and estimated time of arrival.

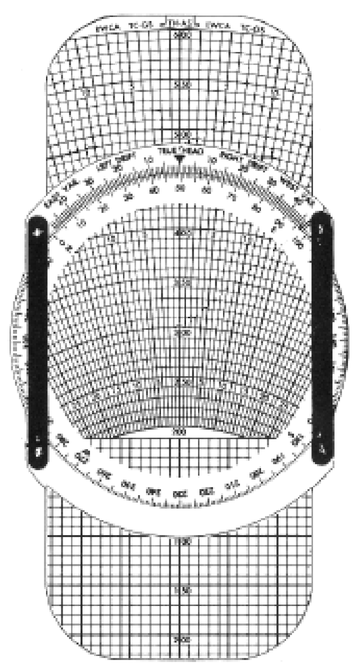

Figure 1: *The legacy E6B flight computer's heading and speed side can solve almost any aviation problem dealing with speed and direction. It can compute actual winds in flight just like modern GPS equipment.*

On an often overlooked page or corner of the display in many GPS systems, is valuable data many pilots may not consider important: computed wind speed and direction. Your GPS computes it every few seconds. Why not use it?

The NWS supercomputers crank out a wide variety of maps and printed data specifically for aviation. The Aviation Weather Center (AWC) displays many of these on its Web site. One of these data types is the FD winds aloft tables, which have been around for decades. These table are available at the AWC web site at: **http://aviationweather.gov/**.

In your training days, you probably worked out tedious, but necessary navigation and aircraft performance problems on an E6B whiz wheel. Some problems involved calculating headings for a flight, given the winds aloft forecast.

You had to use the backside of the computer (see Figure 1) with its round plastic plotting window, azimuth ring, sliding airspeed and ground speed scales. With a pencil, you drew lines and triangles representing those speeds and directions, and you rotated the ring and the window to configure the computer to represent heading and course.

The process was a method to get you to visualize and understand the trigonometry of the problem. It was tedious and careful work to do at a table in the FBO. To plot and calculate the data on an E6B in even light turbulence was about as easy as trying to stuff a porcupine into a can backwards.

If only you had known during the preflight prep what the winds actually were, instead of relying on

Figure 2: *The AWC homepage contains a link to FD Winds and Temperatures aloft. Click on "Winds/Temps (FD)" on the left menu bar.*

an FD forecast, which may have been less than accurate, you could have computed your flight stats accurately. GPS now allows you to do just that and to help others on the ground getting ready to launch.

Each GPS unit uses a different process to access wind data. You need to know how to get the data and to get back to your navigation page. The point is that you can instantly give FSS accurate wind reports every few seconds at any altitude.

The best locations to provide these reports are over or in relation to FD points depicted at the AWC web site. (See Figure 2.) Clicking on "Winds/Temps (FD)" in the left sidebar takes you to the map shown in Figure 3. The FSS, or anyone using DUATS or other services can compare your GPS-computed winds with the FD tables from the NWS. Couple this with an outside air temperature (OAT), and you just pro-

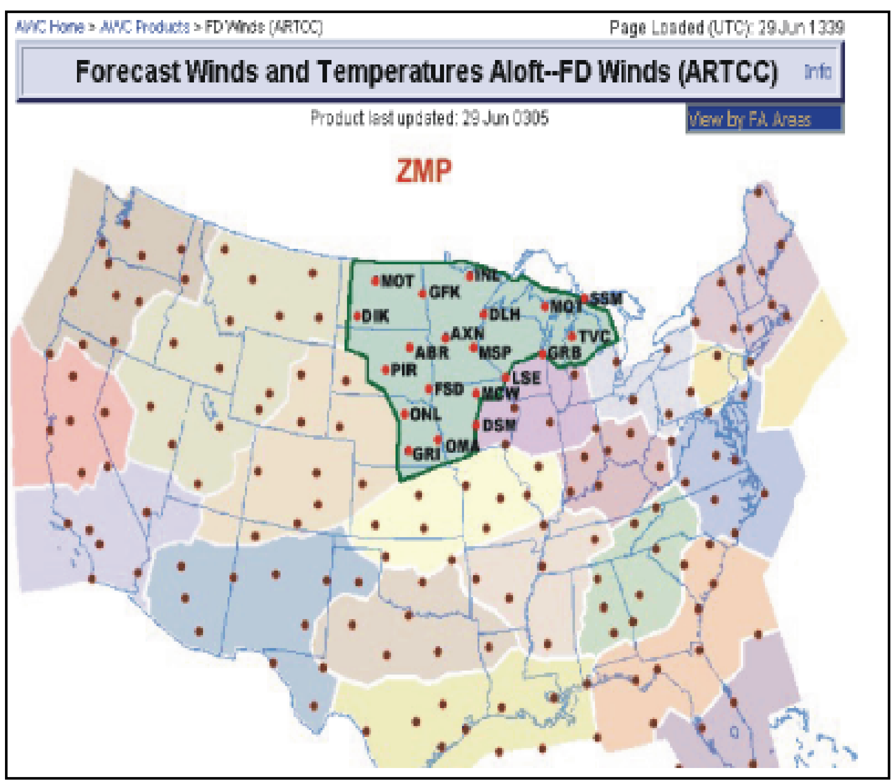

Figure 3: *FD Winds and Temperatures forecast points.*

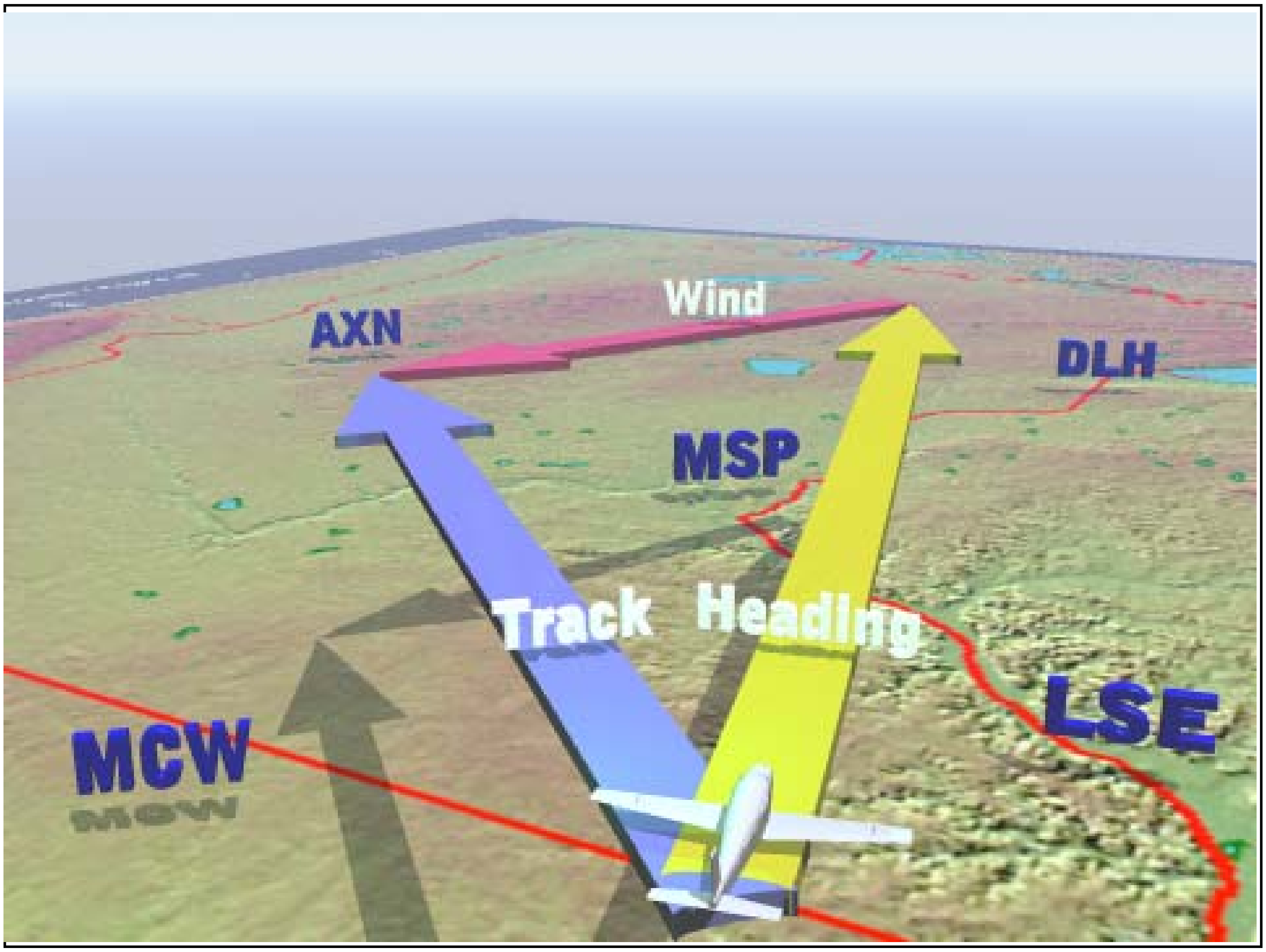

Figure 4: *Three vectors govern your flight: Track, where you want to go. Wind, which blows you off course. Heading, the direction you need to fly.*

vided a valuable update similar to the ACARS reports.

The FD wind forecasts are produced twice a day, once after each new NWS computer run at 0000 UTC and 1200 UTC. There are no computer updates on these products from the NWS. The only update might be from you.

FD points are VOR locations or airports: each has latitude and longitude that you can enter into your GPS as a way point. You also can manually select any of these points and determine azimuth and range from it. Then when you provide a GPS Winds Aloft report, you can reference that FD point. Local briefers know these points like you know your PIN number for the ATM cash machine.

There are three vectors used in navigation problems. (See Figure 4.) The first vector, **Track**, is the line you want to fly over the ground. Ground speed is calculated along that vector. The Track vector can be defined by your points of departure and arrival and by any intermediate way points you choose.

If the air were perfectly still, the wind would not affect your flight. You could just point the ship from point A to point B and fly this track. That doesn't happen often. Wind is usually a factor in pushing you off course.

The second vector is **Heading** or the direction that the plane is facing at any moment. It is the direction you must fly to keep on the desired Track. To maintain this heading requires some rudder trim.

Knowing Track and Heading vectors enables you to calculate the third leg of this flight triangle, **Wind**.

These were the three vectors you used on the E6B or other circular flight computer. GPS solves this trigonometry problem instantly every few seconds. You can display these computed winds aloft if you know where they're stored in your GPS. They might be displayed as an azimuth and speed (260/26) a few pages deep or they might be a simple little graphic in the corner of a navigation page.

Knowing the winds aloft at any point using GPS benefits the whole aviation system by updating the FD wind forecasts.

Your part in reporting these winds is key. You not only help others in the system plan flights more efficiently, but you can also keep updated on your own position relative to weather features like fronts, troughs, temperature inversions, low level jet streams, and storm-related inflow and outflow. ✈

Changing Times, Changing Products, Revisiting the Lifted Index Chart

By Michael Graf, Assistant Program Manager
Aviation Services Branch, NWSHQ

The Internet has made it simple to obtain weather information. But understanding that information and interpreting it quickly can be a challenge. One way to help is to occasionally review the basic weather charts and what's changed.

A chart that's applicable to this time of year and worth review is the lifted index (LI) or composite moisture stability chart. This chart has been taught to pilots and meteorologists for years as a first guess for thunderstorm location and intensity.

I'll review some strengths and limitations of the lifted index, recent improvements, and ways it can help your situational awareness before a flight.

Strengths

1. The LI is a useful tool for quickly determining where the best chance for thunderstorm activity will be. For example you generally will not expect thunderstorms over a region during the convective season when values are positive 2 and higher. On the other hand values less than 0 are usually indicative of some thunderstorm potential.

2. Use the LI as a rough guide for intensity of thunderstorms. See the following chart.

a.	0 to –2	severe potential weak
b.	–2 to –6	severe potential moderate
c.	less than –6	severe potential strong

Limitations

1. The above guidelines for severe potential are generally accepted in the Midwest and eastern United States, but can vary across higher elevations in the West. For example, a -2 at 7000 ft may be as significant as a -6 at sea level. Something a pilot must be familiar with for their local area.

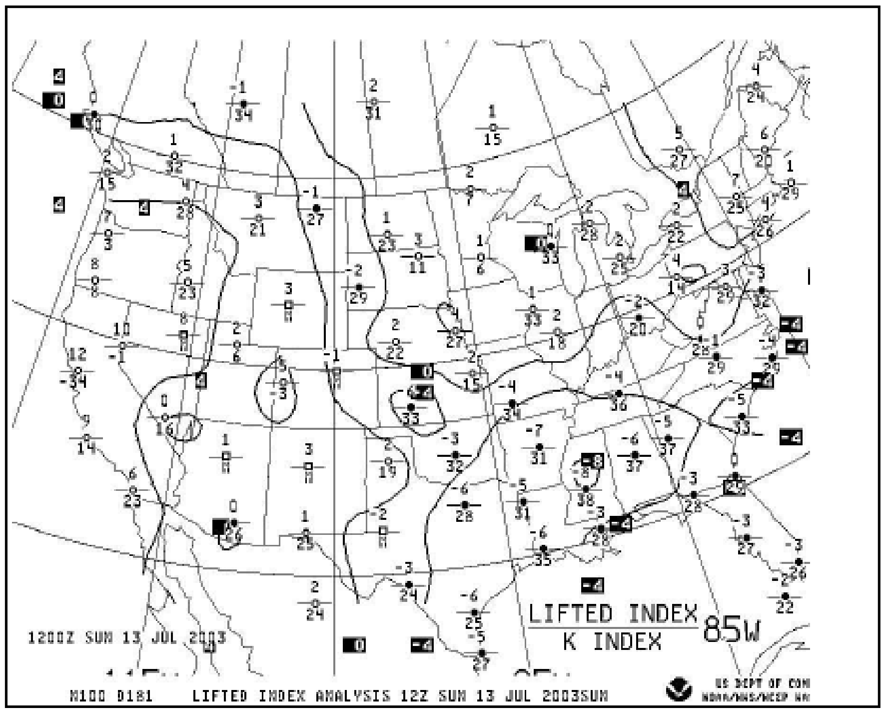

Figure 1: *The Lifted Index or composite moisture stability chart is derived from upper air balloon soundings and helps locate stable and unstable air.*

2. You can have a low LI value (-7) but lack of moisture inhibits convection. Also, a layer of warm air usually around 8,000-10,000 feet can inhibit convection.

3. Many pilots were taught to look at the 00/12Z LI chart. The conditions at these times may change tremendously over the next 6-8 hours, this especially happens with the 12Z lifted index values. For example a 12Z lifted index chart may have a value of +4 over a region, giving the impression that weather will not be a factor. But afternoon heating and/or the addition of low level moisture may drive this value well below a +4, and if condition are right then thunderstorms may result.

4. The reverse can happen, a stable layer of air near the surface results in an LI of +3 and is fairly benign. But instability above the layer where we initially obtained the lifted index value is not taken into account, and thunderstorms develop anyway.

5. Seasonal variations can change LI values referring to severity of thunderstorms. For example an LI of –1 may not seem bad during the summer for the northern Midwest. But if it's spring or fall,

a fast moving line of showers and thunderstorms could produce damaging winds over 70 mph.

For more in-depth information on LI/composite moisture stability chart, click on the following link from the Aviation Weather Service pamphlet ac00-45e, a joint FAA/NOAA publication. **http://www1.faa.gov/avr/afs/afs400/sec09.pdf**.

So with only a few strengths and many limitations, why use LI?

The LI is a good tool used in conjunction with other information like the day 1 and day 2 convective outlooks, as well as current Convective SIGMETs. Also recent improvements in these charts have been chipping away at some of these limitations.

Figure 1 was the only way pilots viewed the LI in the past and was the main briefing tool offered to pilots. It uses soundings from balloons released at 00Z and 12Z to formulate the LI.

This process leads to the limitations mentioned. Recent improvements to the LI chart include better computer simulation of the atmosphere. So rather than just 00/12Z data for the current day, pilots can view an LI forecast for specific hours or even specific days in advance.

See the difference in Figure 2. This is not the real-time data, but forecasted computer model LIs. This chart is a 2 hour forecast from a computer model run every three hours. In this case the model was run at 15Z, and this chart of forecasted LIs is valid for 17Z. Three hours later another model run will occur at 18Z and the entire data set is refreshed. This information comes from the following UCAR site. **http:/www.rap.ucar.edu/weather/model/**.

The strength of these newer charts is demonstrated by reviewing the limitations once again.

- **Limitations 1,5:** Still exists but as pilots get comfortable using these newer charts they'll recognize what local LI values really make a difference for their region and the time of year.

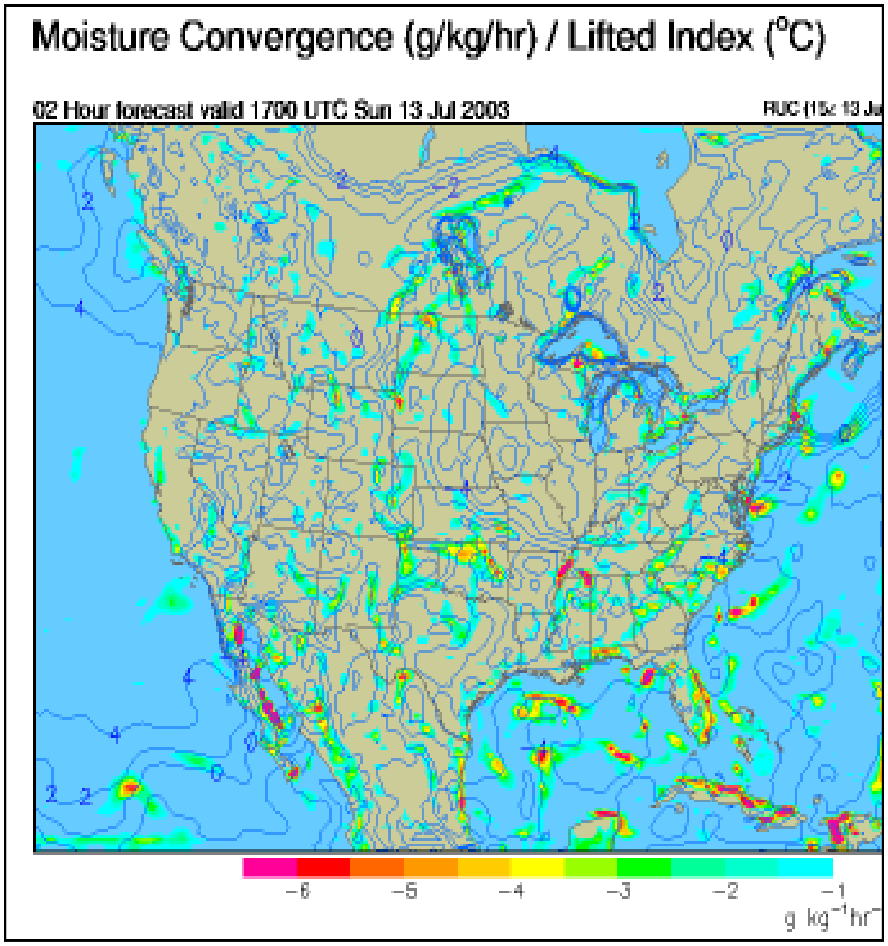

Figure 2: *Forecast Lifted Index chart derived for specific times. The charts help determine stability at times other than 0000 UTC and 1200 UTC.*

- **Limitations 2,4:** For the most part, the rapid refresh rates of the models catch these problems by updating the Lifted indices every 3 hours. But this limitation still holds especially the further out a pilot looks at the forecasted LI.

- **Limitation 3:** Problem gone.

So how can situational awareness be improved? Viewing the new lifted index charts allows the pilot to get a sense of the instability of the atmosphere during and along their route of travel.

By viewing this information in conjunction with other National Weather Service products like the day 1 and day 2 thunderstorm prog charts, convective outlooks, current TAFs and Convective SIGMETs, pilots get a clearer picture of the daily range of the LI. How the atmosphere changes in response to frontal passages and daytime heating or nighttime cooling. Does it become more or less stable?

The end result is the ability to plan ahead and anticipate alternate routes of travel. For example, pilots can use the UCAR Website to prelim trips 3-5 days in advance, click on the GFS suite of products, click on the forecast hour, then LI and obtain forecasted lifted indices for the planned route of travel. Or you can click on the RUC suite of products and look at the forecasted LIs over the next few hours or longer.

As we move ahead in the weather information age, periodically review the basic briefing charts for improvements. Limitations and strengths will change with the improvement of computer models the addition of more real-time weather observations from ACARS and PIREPS. ✈