Raining stats and logs

In the weather derivatives market data is king. **Lynda Clemmons** and **Paul VanderMarck*** find out why

Where would the weather risk management market be without weather data? Well, for a start, two counterparties would not be able to agree on an appropriate price for weather protection without any historical information on the frequency or severity of relevant events. And how would they determine the final outcome of a contract? Could a risk manager confidently explain to senior management that the company's newly purchased weather protection will be settled on the basis of measurements taken by their counterparty, or better yet, that the contract will only be valid if the volunteer running the local weather station maintains it correctly for the entire season? It doesn't take much imagination to realise that the weather market would never have become a viable market were it not for the existence of a reliable infrastructure for monitoring the weather and an abundance of historical data.

Throughout all of the regions in which weather derivatives have been transacted – North America, Europe, Japan and Australia – there are thousands of weather stations operated by government weather services and other national organisations. The most advanced stations take continuous, automated readings of numerous weather conditions including temperature, precipitation, humidity, wind speed, cloud cover and visibility, while others rely on manual observers to periodically record individual weather variables. Some of these stations have been in place for more than 100 years, and most have been around for at least 40–50 years, reflecting post-World War II development projects and the rise of commercial aviation. The discussion that follows will focus primarily on issues associated with US temperature data, the basis of more than 90% of transactions in the weather market to date.

In the US, the National Climatic Data Center (NCDC), a division of the National Oceanic and Atmospheric Administration (NOAA), manages the collection, distribution and archiving of all US weather data. This data is gathered from weather stations operated by the National Weather Service (another division of NOAA), the Federal Aviation Administration (FAA), the military services, the coastguard and a co-operative network of approximately 8,000 volunteer observers, as well as from numerous other sources including ocean buoys and satellites. NCDC reports that it adds more than 50 gigabytes of weather and climate-related data to its archives on a daily basis.

Among all of these sources of data, the primary surface weather observing infrastructure in the US consists of a network of approximately 700 weather stations, which have been upgraded with the latest automated surface observing system (ASOS) instruments over the past decade. The ASOS programme is a joint venture of the National Weather Service, the FAA and the Department of Defense and is operated to support aviation safety, weather forecasting, and meteorological and climatological research. Weather stations with ASOS instruments are generally considered to be the most reliable sources of data owing to their automated recording processes and standardised equipment, while data from the co-operative stations is usually considered the least reliable because they usually use older instrumentation, inconsistent observation schedules and manual observation processes. Approximately 300 of the ASOS-equipped stations are known as 'first order' stations, meaning that their historical records include on average 25 or more years of hourly observations taken by trained, certified observers before the switch to ASOS instrumentation during the 1990s.

NCDC provides much of its data directly over the Internet from its website at www.ncdc.noaa.gov. Figure 1 shows an example of ten-years of daily average temperatures for the Chicago O'Hare Airport weather station. The seasonal cycles are clearly observable, as are fluctuations in extreme values from year to year (see graph).

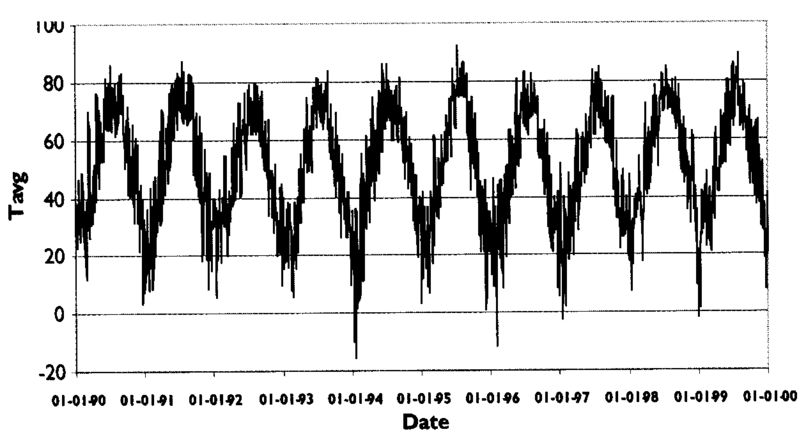
At the present time, the weather market trades predominantly on the basis of 30–40 first order airport weather stations near major population centres throughout the US. The market has gravitated to these sites because of the quality of their historical data as well as the security at the sites and the resulting reliability of future observations.

On a global basis, other national meteorological agencies have compiled similar archives of historical data. Although the extent of weather station networks and the modernisation of instruments vary from country to country, the fundamental data necessary for analysing weather risk usually does exist. The main hurdle internationally is the cost and ease of obtaining the data.

In contrast to the US, where official government policy is to provide data for a nominal fee that reflects distribution costs, some countries charge much higher fees in an attempt to recover a share of the cost of collecting the data, or even to operate their meteorological networks as 'for-profit' operations. In comparison to the US situation where the availability of data has aided the rapid development of the weather market, the market has grown slowly in places like Europe where high data costs have been a significant obstacle to interested participants. As progress has been achieved toward cost reductions in individual countries, there have been commensurate increases in weather market activity. However, costs generally still remain much higher for data everywhere outside of the US.

In the weather market, historical weather data is an absolute necessity for product valuation. In the most basic of examples, raw historical data gives a rough estimate of the potential cost of a weather product. For example, Joe at Acme Heating Oil Company knows that Acme's

Figure 1. Daily average temperatures at Chicago O'Hare over last ten years



transaction based on the number of HDDs recorded at a nearby airport weather station for the upcoming November to March winter season, and that a recent movement of the station to an outlying area away from the terminal buildings caused a discontinuity of –1.0°F in the daily temperature recordings relative to those prior to the move. An analysis of the historical data that does not account for this discontinuity will indicate a mean number of seasonal HDDs that is 151 (one degree for each day in the risk period) fewer than the true mean based on how weather is being recorded at the current weather station location. With standard contract structures paying out $5–10,000 per degree day, identifying and accounting for such discontinuities is a critical element of the valuation process.

Unfortunately, detecting and quantifying discontinuities is not a trivial undertaking. The natural variability in day-to-day temperatures creates a substantial amount of 'noise' from which it is challenging to isolate the 'signal' that is the signature of a discontinuity. As a result, despite widespread acknowledgment of these issues, the problems in using raw historical data have been an obstacle to price discovery and increasing liquidity in the weather market.

In the first independent analysis of the topic, Risk Management Solutions and Earth Satellite Corporation recently announced the completion of a project to address discontinuities in historical weather data. The two companies jointly developed a new methodology that blends meteorology and statistical science and used it to produce a database of enhanced historical temperature data for 200 first-order US weather stations.

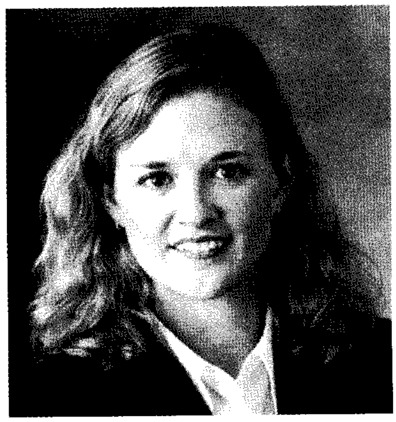
The methodology analyses potential discontinuities in a station's history by running a series of statistical tests on the differences in temperature before and after a particular date between the target weather station and a weighted combination of its neighboring stations. Once discontinuities are identified and quantified relative to this stable reference, the historical data is adjusted to create a final time series of historical daily values that is as consistent as possible with how temperatures are being recorded today.

A profile of the 200 stations of enhanced historical data provides good insights into the relevance of these data issues to the weather market:

- The average weather station has, based on NCDC reports, experienced 13 events over the past 50 years that were potential causes of discontinuities.
- Almost 90% of weather stations have at least one discontinuity in their records over the past 50 years, with some having as many as eight in the last ten years alone
- Approximately 50% of weather stations have at least one discontinuity in their records
- The average magnitude of all discontinuities in daily average temperatures is 0.8°F, with discontinuities as large as 2.5°F present in some station data
- More than one-third of discontinuities occur at dates not included in NCDC's reports on station histories, in many cases representing events such as construction projects that affected a weather station's environment but that would not have been noted by the weather service

The presence of these discontinuities in weather data is easy to understand when you recognise that the National Weather Service has never run its network of weather stations with a goal of providing a consistent and homogeneous historical record for the purposes of pricing weather risk contracts. While the weather market exists because of the work of the National Weather Service, the reverse is not true.

Advancements over the past several years in the understanding and interpretation of historical weather data have been vital to the growth of the weather market. Ongoing research initiatives and efforts to achieve greater international consistency in data availability and transparency can be expected to manifest themselves in continued market growth.■



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