18.2 TRACKING NWS AREA FORECAST DISCUSSIONS TO STUDY THE
SUBJECTIVE USE OF WIND AND TEMPERATURE PROFILER DATA

Douglas W. van de Kamp and Daphne M. Grant

NOAA Research-Forecast Systems Laboratory, Boulder, Colorado

1. INTRODUCTION

National Weather Service (NWS) forecasters use many different products when preparing their forecasts, including surface and aircraft observations, balloon soundings, satellite imagery, profilers, and numerical model guidance, to name a few. We have been studying how NWS forecasters utilize wind profiler data in their decision-making process. Two general types of wind profilers were the focus of this study: the NOAA Profiler Network (NPN) and the Cooperative Agency Profilers (CAPs). We used an automatic search program to monitor the NWS Area Forecast Discussions (AFDs) to help us gain a better understanding of the geographical distribution of the data being used, and how often and in what ways the NPN and CAP profiler data have been subjectively used at NWS forecast offices.

2. BACKGROUND

A profiler is an all-weather, unattended, vertically pointing clear-air Doppler radar. The primary purpose of a profiler is to measure hourly (or sub-hourly) profiles of wind speed and direction, however many profilers also measure the vertical temperature structure of the lower troposphere. The NPN profilers measure clear-air signals within the troposphere and lower stratosphere, while the CAP profilers typically measure signals only in the lower troposphere. The Demonstration Division of the Forecast Systems Laboratory (FSL) operates the 35 NPN sites in cooperation with the NWS, and provides access to real-time data from all NPN sites to the NWS and many other worldwide users. The sites are primarily located in the central U.S. (See Fig. 1.), with three sites located in Alaska. NPN data are available for use by NWS forecasters in two distinct ways; subjectively by viewing the

Corresponding author address: Doug van de Kamp, NOAA R/FS3, 325 Broadway, Boulder, CO 80303; e-mail: Douglas.W.vandekamp@noaa.gov.

data on AWIPS (Advanced Weather Interactive Processing System), and objectively by the assimilation of profiler observations into routine Numerical Weather Prediction (NWP) model runs. NPN data have been shown to have a positive impact to NWP, both within the U.S., as described by Benjamin et al. (2004), and by the European Center for Medium-Range Weather Forecasting, described by Bouttier (2001).

Cooperative Agency Profilers are not installed, operated, or maintained by the Demonstration Division of the Forecast System Laboratory. Participants in the CAP program within the Demonstration Division primarily take advantage of the existing NPN processing infrastructure to disseminate their profiler data to a broader community of users. In cooperation with the CAP owner/operator, the Division acquires their CAP data using various communications methods (FTP, dial-up, web sources and GOES-DCP system), and provides the data in real-time on the Division's Profiler web page at www.profiler.noaa.gov. This greatly reduces the burden on some of the CAP owner/operators to provide data display capabilities to support their use of the data. The web site provides many display and download options for their use, including archived data for several years, various wind and temperature scaling options, and additional data display options. In addition, CAP participants are providing access to their data, for the benefit of the entire meteorological community.

The CAP data are also routinely sent to the NWS Telecommunication Gateway, using the existing NPN communications infrastructure. This allows the easy dissemination of NPN and CAP data to NWS National Centers, including the National Centers for Environmental Prediction (NCEP), and the rest of the world. NPN data are routinely assimilated into numerical model runs at NCEP, but CAP data are not at this time. Also, AWIPS cannot display CAP data at this time, but will be able to in the future.
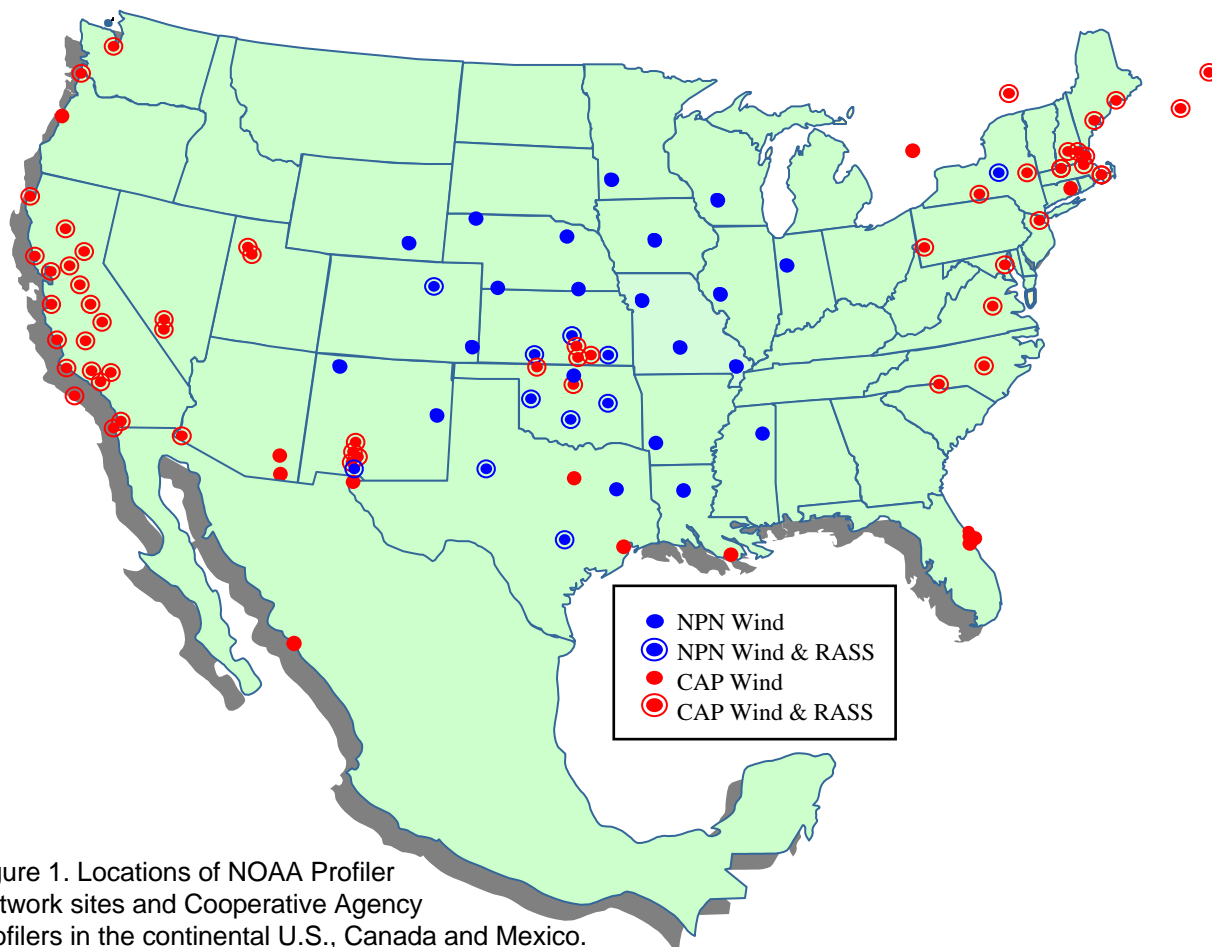
Figure 1. Locations of NOAA Profiler
Network sites and Cooperative Agency
Profilers in the continental U.S., Canada and Mexico.

Over 100 CAP sites are currently available, including 31 from Japan. Over 30 different sources, or "Cooperative Agencies" provide access to their profiler data, including 11 federal agencies, 13 state agencies, 5 universities (including one in Canada), 1 private company and 3 foreign agencies (located in Canada, Japan and Peru). CAP sites are not just "Boundary Layer Profilers" anymore (although the majority of them are, and they are primarily used in support of air quality activities). The CAP sites are generally located near populated areas along the east and west coasts of the U.S. (See Fig. 1).

3. DISCUSSION

In order to determine the extent to which NWS forecasters subjectively use profiler data to help make their forecasts, we looked through all of the AFDs that the NWS forecasters produced daily for any reference to a wind profiler. Each individual NWS forecast office typically writes two AFDs each day to describe current forecasting issues, both for the short-term and longer-term forecast periods. These AFDs are generally technical in detail and represent a several paragraph "thought process" to be shared among

forecasters within an individual forecast office between shifts, and with adjacent NWS offices. An automatic search program scanned all AFDs for the period 6 January 2003 – 5 January 2004 for any mention of the word "profiler." For any AFD that registered positive for the word profiler, we identified the particular NWS office, the date and time of issuance of the AFD, the specific wind profiler site or general geographic region, and in what way the profiler data assisted the forecaster(s). An example AFD is provided below. Only the relevant profiler reference portion is included.

HASTINGS NE 400 AM CDT FRI AUG 8 2003

PROFILER NETWORK SHOWED SHORTWAVE POSITION IN WESTERN SDAK AND NEB AT 700 MB. STEERING WINDS AT MCCOOK...WHICH IS WHERE CONVECTION IS CURRENTLY ONGOING...ARE VERY LIGHT CONFIRMING SLOW MOVEMENT OF STORMS. COMPARED 500MB PROFILER WINDS WITH 06Z GFS AND IT LOOKS LIKE MODEL IS OVERDONE WITH STRENGTH OF 500 WAVE TO OUR IMMEDIATE WEST.

4. RESULTS

Out of the ~120 NWS forecast offices in the United States, a total of 79 offices specified using profiler data in at least one of their AFDs in the one year period. Figure 2 displays the geographical location of these offices and how often they cited the use of profiler data. Note that the spatial distribution is very similar to that of all of the NPN and CAP profiler sites shown in Figure 1.

The NWS offices located in the central U.S. are of course primarily using NPN data, while those offices near the east and west coasts are primarily using CAP data. There are several interesting things to note. The NWS San Francisco office mentioned the use of profiler data the most, 149 times. Two of the three NWS offices mentioning the highest usage of profiler data are located in California (and obviously using CAP data). Chicago was number four, with 88 references to profiler data. This is very interesting, considering that both San Francisco and Chicago have access to a large number of local profiles from ascending and descending aircraft. The NWS offices in Alaska have identified the use of profiler data in special weather event summary reports, but never specifically identified the use of profiler data in any of their AFDs during this one year period.

Of the 79 offices indicating their use of profiler data, a total of 1882 AFDs (averaging about 5 per day) reported using profiler data in their decision-making processes. More than half of these AFDs could be identified as to the type of profiler being referenced. The use of NPN data was indicated 533 times, while CAP data was indicated 507 times. We could not easily tell which profilers were being referenced in the remaining ~850 AFDs.

5. SPECIFIC USES OF PROFILER DATA

The AFDs were also categorized, related to how the profiler data were utilized in the forecaster's decision making process. In many cases it was apparent they were using profiler data for general "situational awareness". In addition, very specific uses were also identified, including NWP and cloud drift wind validation, issuing/canceling of high wind watch/warnings and red flag fire weather forecasts, and aviation related low-altitude wind shear advisories. It should also be noted that some AFDs (~20%) mentioned multiple uses of profiler data within one AFD, such as the earlier example from Hastings, NE (referencing use in the "Lower Troposphere" and "Model Wind Validation" categories).
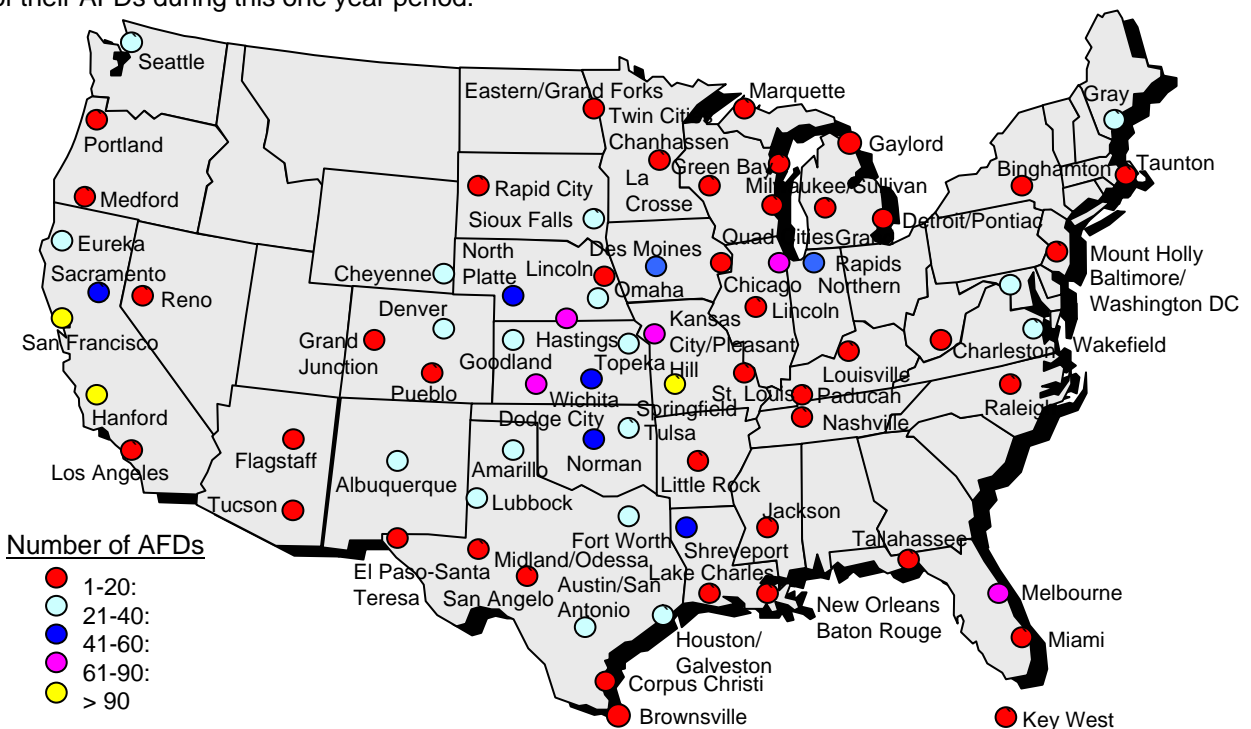

Figure 2. Locations of NWS offices identifying use of profiler data in their Area Forecast Discussions. Also Identified are the individual offices total number of discussions mentioning the use of profilers for the period 6 January 2003 – 5 January 2004.

In reading through all the AFDs, we initially identified approximately 40 unique, or specific, uses of profiler data. By combining similar subcategories of the 40, we identified 10 significant categories of profiler usage, plus one smaller "Other" category, as shown in Figure 3. A short description of each of these 11 categories is presented below, along with identifying many of the smaller, specific categories that were combined within each major category.

- Atmospheric Feature. The largest, rather general category, related to "Situational Awareness", and used often whenever an atmospheric feature was **not** identified in terms of height (Upper or Lower Troposphere, Boundary Layer, or Marine Layer). This category was mentioned 380 times in the AFDs. Subcategories included references to backing/veering winds, warm/cold air advection, shear, air mass temperature, saturation/cloud generation, changing wind speeds, short wave location, and closed circulation centers.

- Model Wind Validation. The first category identifying a very specific use of profiler data. The category was mentioned 338 times in the AFDs. Subcategories included references to profiler winds closely matching NWP, and measured winds stronger or weaker than predicted by NWP.

- Lower Troposphere. Another rather general category, and also related to "Situational Awareness" specifically in the lower troposphere. Mentioned 318 times in the AFDs. Subcategories included references related to measured strong winds above the surface or in the lower range gates, an increasing low-level jet, constant winds at low-levels, or decreasing winds at low-levels.

- Satellite Wind Validation. Another very specific category of use of profiler data. Mentioned 248 times in the AFDs. The category included references related to validating cloud drift winds.

- Boundary Layer. Mentioned 209 times in the AFDs. Subcategories included references related to surface, mesonet, buoy, tower, and sodar measurements, related to the boundary layer depth, mixing, and depth of inversions.

- Radiosonde Soundings. A very specific use of profiler data. Mentioned 184 times in the AFDs. The category included references related to comparing profiler and radiosondes winds.

- Marine Layer. A very specific use of profiler data. Mentioned 183 times in the AFDs. Subcategories included references related to the depth of the costal marine layer analyzed from the profiler (CAP) wind and temperature measurements, identified primarily by NWS offices located in California.

- NEXRAD. A very specific use of profiler data. Mentioned 132 times in the AFDs. Subcategories included references related specifically to comparing profiler and VAD winds, and a general subcategory identified as radar comparisons.

- Upper Troposphere. Specifically mentioned 96 times in the AFDs. Subcategories included references related to the position and orientation of upper level troughs, and jet stream related winds.

- Satellite Imagery. Specifically mentioned 92 times in the AFDs. The category included references related only to features seen in the water vapor imagery (no mention of the use of visible or IR imagery in conjunction with profiler data was ever made).

- Other. Mentioned 56 times in the AFDs. Subcategories included references related to Aircraft (ACARS) validation and pilot reports, snow level, lake/ocean effect snow, and profiler wind bias due to migrating birds.

Some overlap between specific categories was noted, e.g., "Lower Troposphere" and "Boundary Layer".
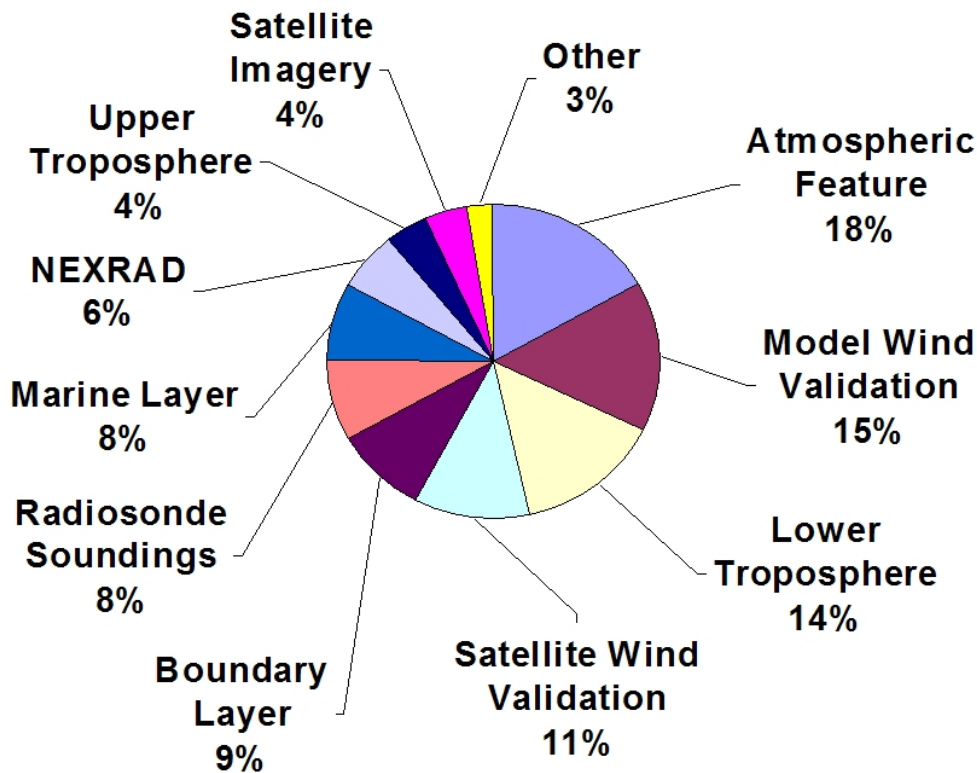
Figure 3. Categories of profiler data usage identified from the Area Forecast Discussions. See Section 5 for details.

The above categories identify the broad use of profiler data in NWS operations, including both the 35 sites in the NPN and the approximately 100 CAP sites. The NWS's Storm Prediction Center (SPC), located in Norman, OK, also use profiler data extensively, primarily for assessing lower tropospheric helicity, and identifying the strength and position of upper-tropospheric jet features. Also, although the SPC do not produce AFDs (but they do identify use of profiler data in their Mesoscale Discussions), access to real-time winds is very important to severe weather forecasting for the SPC and many NWS offices, particularly between the times of the twice-daily radiosonde ascents.

In addition to counting and categorizing AFDs that mentioned the use of profiler data, we also used FSL web sites (http://maps.fsl.noaa.gov/sfd/, and http://acweb.fsl.noaa.gov/docs/fcst-disc/?O=D) to investigate AFDs that mentioned the use of the RUC (Rapid Update Cycle) model, and the use of ACARS aircraft data. This was simply done as an easy check, or validation, of our procedure. No detailed evaluation was performed concerning how the data were used, but we did a simple count of how often "RUC" or "ACARS" (and other aircraft related terms) were identified each day in the AFDs, for the same one year time period as the profiler evaluation. The results are presented in Figure 4, including the daily count of AFDs that mentioned the use of profiler data. It can be seen that the daily counts of AFDs that mention the use of profiler data, generally falls between the RUC and ACARS daily counts. This seems entirely consistent to us, with ACARS data being available over the entire U.S., but basically limited to constant flight level data and ascent/descent profiles near major airports. And RUC data being available over the entire U.S., at all levels, and routinely used in short-term forecasting. The use of profiler data mentioned in the AFDs appears to be about half as often as the RUC, and is consistent when compared to the somewhat limited spatial coverage of profilers over the U.S. (See Fig. 1).

6. SUMMARY

We categorized all NWS Area Forecast Discussions based on the usage of the word "profiler". We focused on the two general types of wind profilers: the full tropospheric coverage NOAA Profiler Network, and the primarily boundary layer Cooperative Agency Profilers. This study investigated the geographical distribution of the data being used from the ~135 profilers, and how often and in what ways the NPN and CAP profiler data have been subjectively used at NWS forecast offices.

We found that the use of profiler data is well integrated into routine NWS operations, in areas where profilers are located nearby. The AFDs were categorized based on how the profiler data were utilized in the forecasters decision making process. It was apparent they were using profiler data for many applications. In addition to general "situational awareness", specific uses were also identified, including NWP model wind forecast and cloud drift wind validation. Profiler data were found to be valuable in their watch, warning and advisory responsibilities, particularly between the times of the twice-daily radiosonde ascents.

REFERENCES

Benjamin, S. G., B. E. Schwartz, E. J. Szoke, S.E. Koch, 2004: The Value of Wind Profiler Data in U.S. Weather Forecasting. In Press, Bull. Amer. Meteor. Soc., Dec. 2004.

Bouttier, F., 2001: The Use of Profiler Data at ECMWF. Meteorologische Zeitschrift, **10**, 497-510.

Profiler, RUC, & ACARS data mentioned in AFDs from Jan. 6, 2003 – Jan. 5, 2004.
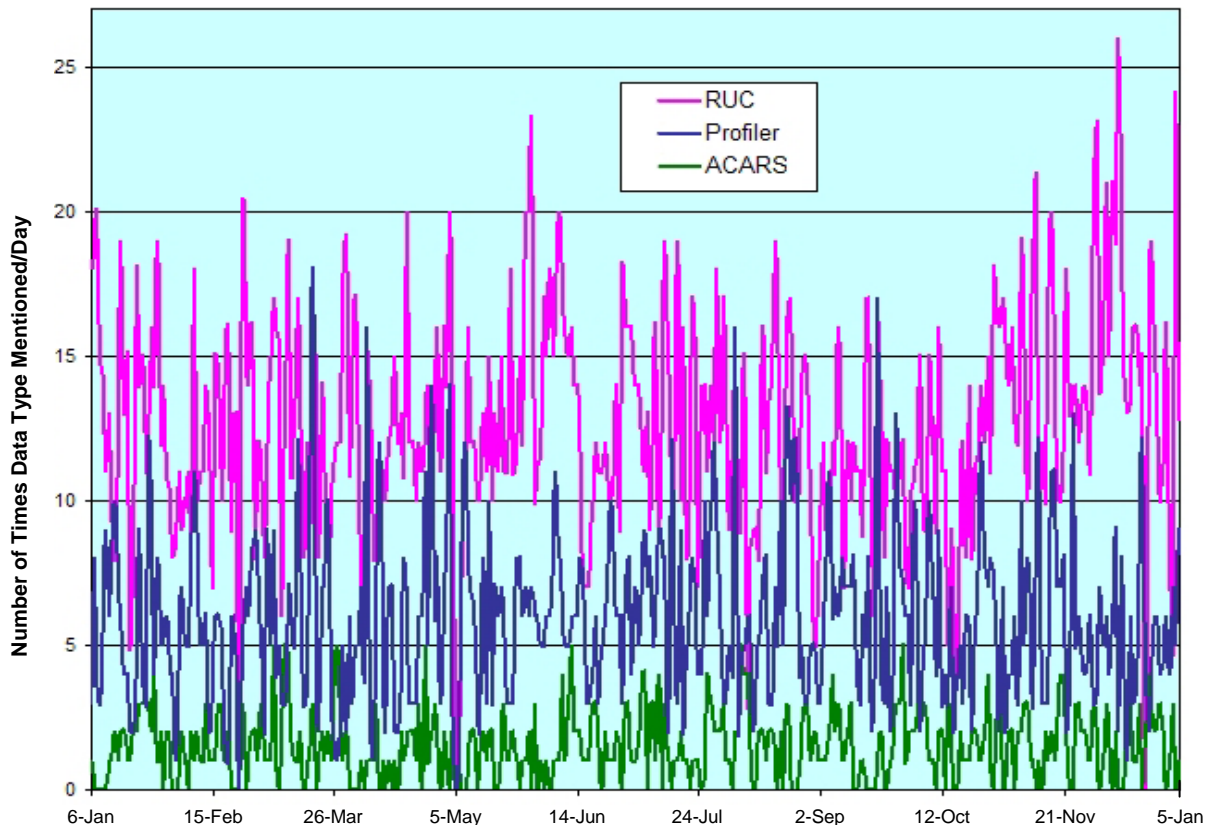

Figure 4. Daily counts of how often "Profiler", "RUC", and "ACARS" were identified in the AFDs, for the same one year time period as the profiler evaluation.