APPENDIX: Results from a comparison of Editsonde and ASPEN

We chose two random samples of 100 dropsondes each that were dropped into the eyewall from the NOAA P3 aircraft and in the TC synoptic environment from the NOAA G-IV jet. The output files generated from the NOAA drops were created in real time aboard the aircraft. These sondes were subsequently processed with ASPEN using the same QA parameters as Editsonde. The handwritten logs filled out by the dropsonde scientists on the NOAA aircraft were used to identify sondes from the random samples that required intervention by the operator as part of the QA procedures. The logs were also used to determine the type and frequency of problems encountered with the dropsondes.

Seventy-eight of the 100 eyewall sondes required some operator intervention, particularly those that failed to transmit data all the way to the sea-surface. Others manual procedures include corrections for a dry relative humidity (RH) bias, pressure bias corrections, corrections to flight-level data from a delayed launch detect, additional filtering of noisy winds, and corrections for sensor wetting. About 1/3 of the 78 “problem” sondes needed a correction to the automatic selection of the “splash” point in the drop in order to correctly determine the altitude of the observations. Many of the corrections made in real time with Editsonde would not have been possible with the ASPEN software.

Examples of the types of differences in the data output from Editsonde and ASPEN for sondes that required operator intervention are in Figure 1. The first example (Fig. 1a) is from a sonde that had weak wind telemetry at low levels. Here the operator chose to retain the low-level winds in Editsonde while the automatic QA algorithms in ASPEN rejected this data as faulty. Note that the winds from both software suites generally track together between 750 and 880 mb but there are still substantial differences of 2-3 m/s in the wind minima and maxima.

The example from Fig. 1b indicates a large offset in the temperature profile between Editsonde and ASPEN. This is a result of a failure of the sonde to transmit data all of the down to the surface. The automatic algorithms in ASPEN incorrectly identified the last data record as a “splash” point, resulting in incorrect height assignments to the observations. Although the ASPEN operator can override the automatic assignment of a “splash” location, ASPEN does not have the diagnostic ability that Editsonde has to be able to always determine the correct “splash” data record or whether or not the transmitted sonde data reached the surface. It should also be noted that while the offset in the two temperature profiles constitute the main difference, there are additional noise and spikes in the ASPEN temperature profile.

The RH profiles in Fig. 1c are offset because a bias correction was applied in the Editsonde processing, a capability not currently available in ASPEN. The dry bias is a result of molecular contamination of the RH sensor by airborne particulates, is somewhat random and unpredictable, and can have a magnitude of 5-20% in RH. Although this known dry bias (Wang 2005) has been minimized with the inclusion of a humidity sensor cap by the sonde manufacturer, sondes that have been removed from their packaging prior to a flight (a common occurrence) are still subject to this dry bias. In fact, NOAA sonde operators have seen batches of sondes that exhibited this dry bias as recently as the 2006 hurricane season and have only been able to correct the data if Editsonde was used on the flight.

While some of the differences in the output from ASPEN and Editsonde in the eyewall sample are attributed to manual intervention by the software operator, some are because of differences in the QA algorithms themselves. Examples of these differences are in Fig. 2. The wind profiles in Fig. 2a differ substantially at particular heights below 1500 meters. The winds in this portion of the profiles are extreme (60-80 m/s) and are associated with strong updrafts encountered in the hurricane eyewall. The algorithms in ASPEN are unable to correctly process data in updrafts where the upward air motion exceeds the terminal fall velocity of the sonde (about 12 m/s near the surface). In these cases, ASPEN removes data within these updrafts where Editsonde retains the data that often contain detailed structure and the strongest wind peaks. Even though these extreme horizontal and vertical winds are relatively rare (< 5% of all eyewall drops), they occur in the strongest and most rapidly intensifying storms that are of great interest to forecasters.

A sample of sondes from these extreme eyewall events were studied and an example of the results are presented in Fig. 3. Here, the lowest 150-m wind average computed from ASPEN and Editsonde are plotted. This 150-m wind average (WL-150) is transmitted in the TEMDROP message for use by forecasters at NHC and is designed to be more representative of a near-surface sustained wind than an individual observation would be. The two software packages reported wind differences >2 m/s, significantly greater than the measurement uncertainty, in about half of the sondes in this sample. There were also height differences of tens of meters (not shown) between Editsonde and ASPEN output from these sondes.

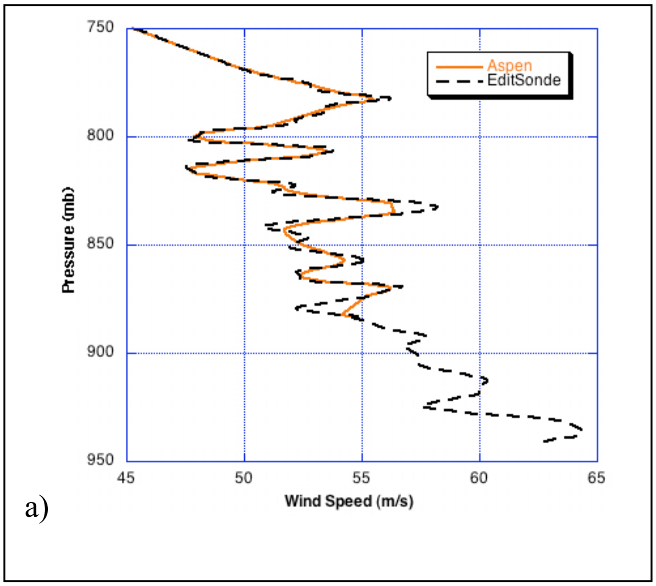
Although sonde released in the turbulent, high-gradient region of the hurricane eyewall require a lot of manual correction to the data, sondes dropped in the relatively quiescent area surrounding a TC still often require some corrections in the QA software process to ensure correct and high-quality data transmission. Of the 100 random sondes released from the G-IV uses in this study, 48 required some intervention by the Editsonde software operator. Of these 48, 17 were chosen for the comparisons that represent the most varied yet common types of problems inherent in the sonde data. Of the 17 dropsondes, 2 had faulty or a non-exiting launch detect. Editsonde was able to process the thermodynamic data in these 2 sondes, while ASPEN produced no output. The ASPEN and Editsonde output from the remaining 15 sondes were compared and some of the results are in Figure 4.

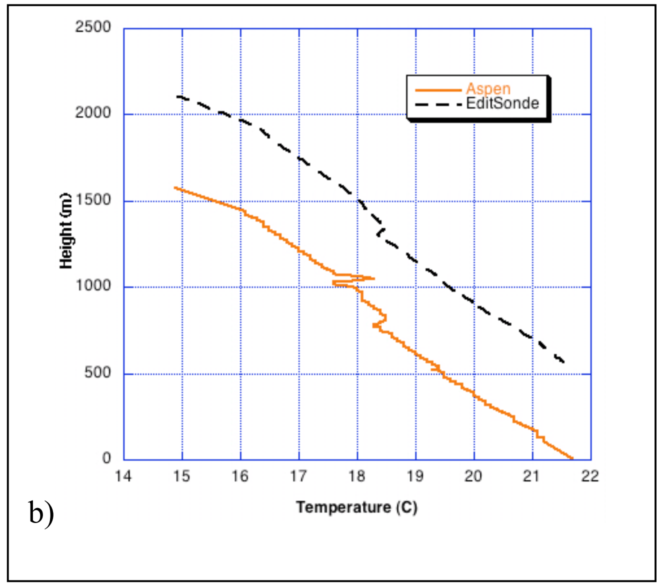
Histograms of difference calculations in the output from Editsonde and ASPEN are in Fig. 4a-c. About 80% of the data points have differences that are close to the uncertainty in the measured variables (wind speed, temperature, and RH) themselves but the remaining 20% of the data can contain differences that far exceed the uncertainties. The wind calculations (Fig. 4a) compare the most favorably with 95% of the observations being within 2 m/s from the two software suites. Only about 3% of the wind data in the synoptic G-IV sample contain wind differences greater than 5 m/s. A similar sample size of eyewall drops (not shown) contain >5% of wind data with differences > 5 m/s.

The temperature differences (Fig. 4b) show that about 10% of the data contain differences >1°C, much larger than the measurement uncertainty. The differences in the RH measurements (Fig. 4c are the largest of those shown with about 12% of the data contain RH differences >5% and the largest range of differences with RH values between the ASPEN and Editsonde output having differences as large as about 40%.

The actual differences in the full-resolution output from ASPEN and Editsonde in the 15 sonde G-IV sample are in Figure 4d. Since the data from the two sets of software do not produce the same number of output records, a careful matching of the data was necessary to properly compare the differences in this figure and those from Figure 4 a-c. The differences shown in Figure 4d can be thought of a time series of individual observations and are representative of the types of problems that could be encountered on synoptic surveillance flights. Almost all of the sondes show differences in RH of 2-5%, with 2 of the sondes reporting differences of >20% in RH. The temperature differences are small in most of the sondes but 3 of the 15 sondes had temperature differences >2°C. Wind differences are similarly small overall with 3 of 15 sondes reporting wind speed differences >4 m/s and 2 with differences between 5 and 10 m/s.

It is difficult to assess how many sondes on a particular flight might require intervention by the sonde software operator and how many sondes might contain corrupt data if processed automatically. The types of problems presented here are typical of those found in eyewall and TC environmental sonde data. Problems tend to occur sequentially from manufacturing inconsistencies or from improper handling of the sondes prior to a flight (dry bias). An inspection of a much larger sample of sondes (~500 G-IV synoptic, ~300 P3 eyewall) shows that the frequency and types of problems presented here are representative of a larger sample. About 75% of the G-IV flights have sondes that require operator intervention to correct faulty data while nearly 100% of the inner core P-3 flights have sondes that require corrections. Sometimes only 1 or 2 sondes on a particular G-V flight needs correction while in a few cases nearly half of the sondes require some manual QA procedures. Typically, about half of the inner core sondes released from the P3 require a trained operator to correct the data and some of the corrections on both the G-IV and P3 sondes can only be corrected using the capabilities built into Editsonde.





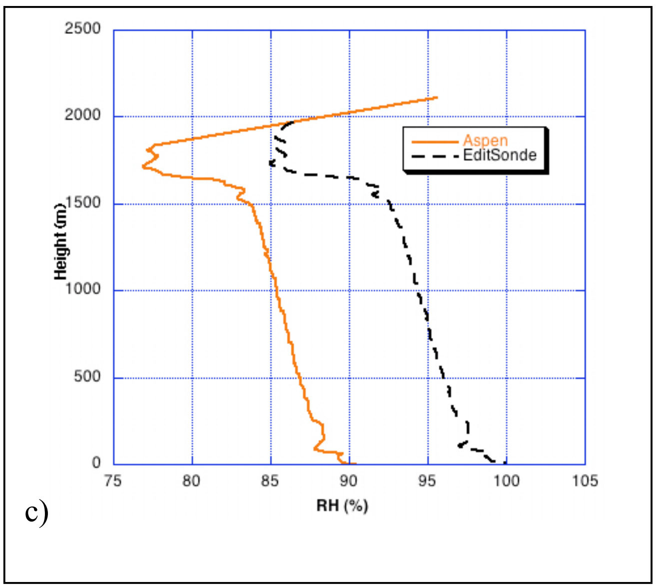
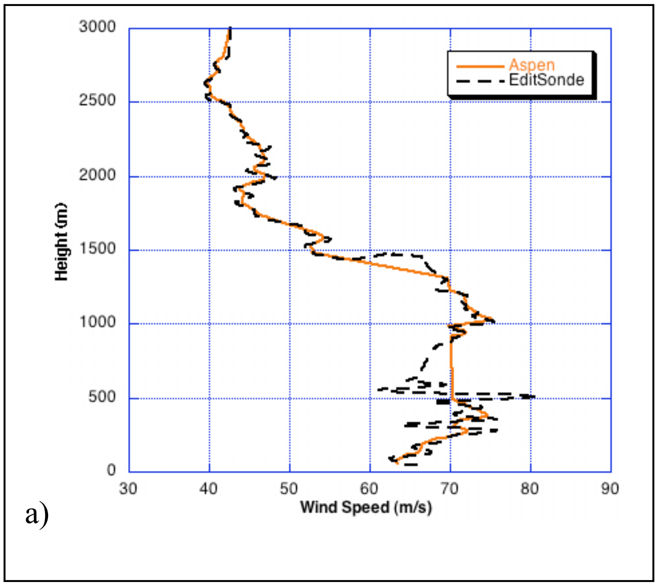
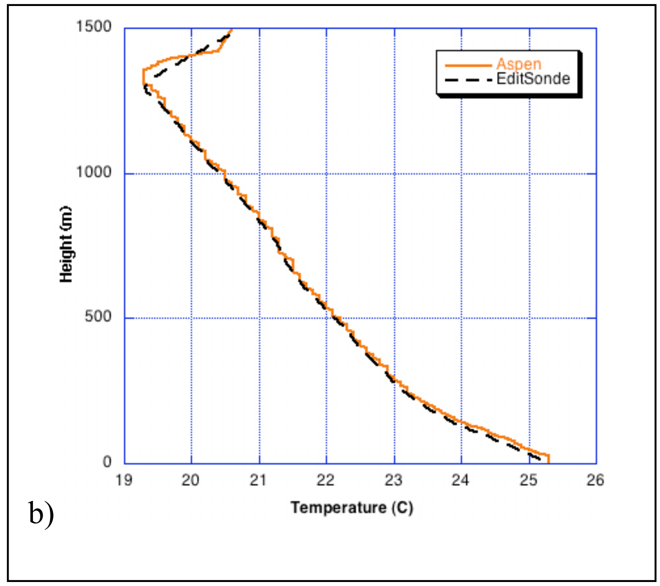
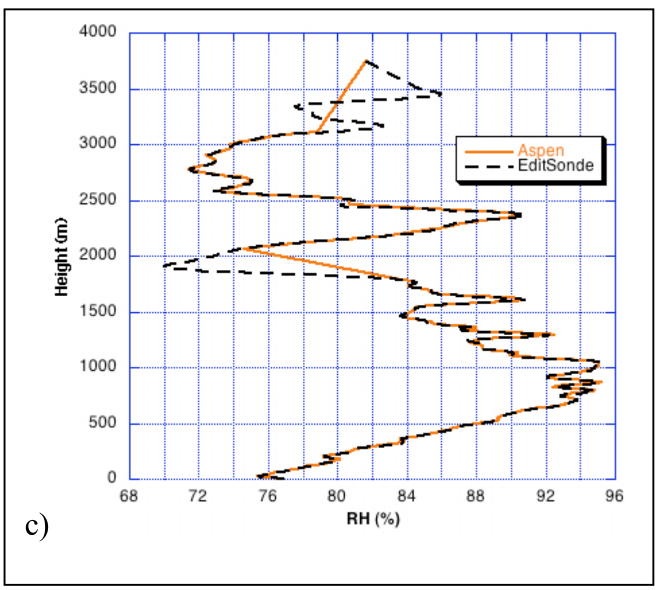


Fig. 1. Comparisons in the output generated by the ASPEN and Editsonde QA procedures for select eyewall sondes released into the hurricane eyewall from the NOAA P-3 aircraft. The wind speed profiles are in (a), temperature in (b), and the RH profiles are in (c). These are sondes that required manual intervention by the Editsonde operator.







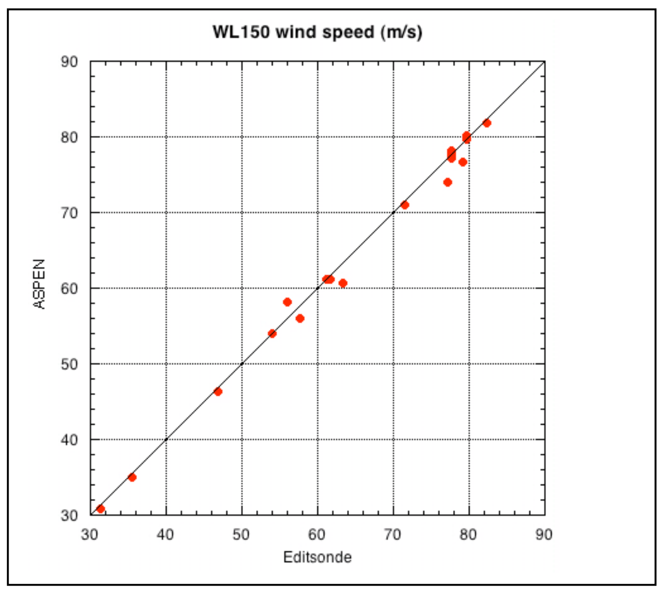
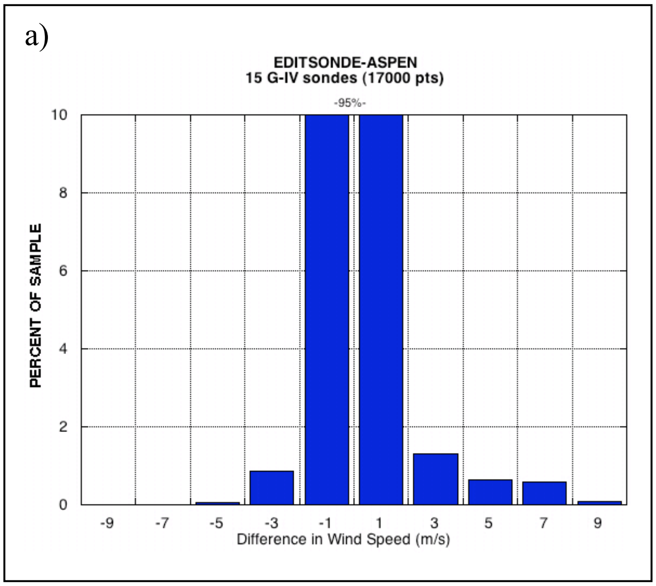
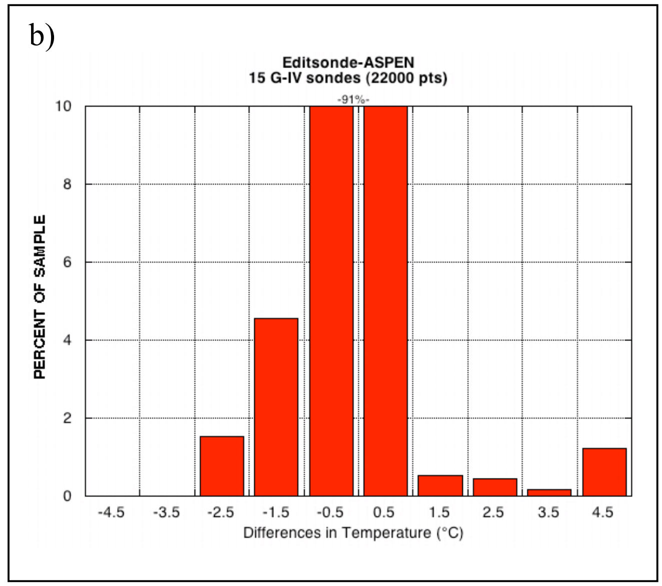
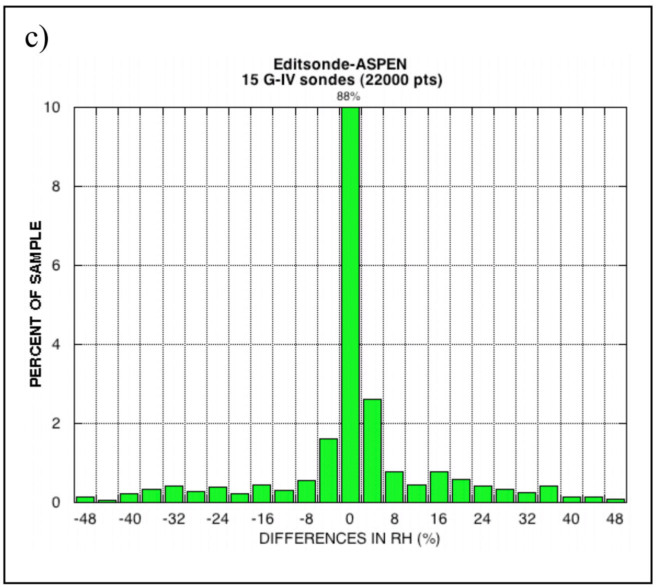


Fig. 2. (a)-(c), As in Fig 1, except for P3 eyewall sondes that demonstrate differences in the algorithms between Editsonde and ASPEN.

Fig. 3. A comparison of the computation of the lowest 150-m wind speeds (WL-150) between ASPEN and Editsonde for an eyewall sonde sample with updrafts greater than the sonde fall velocity.







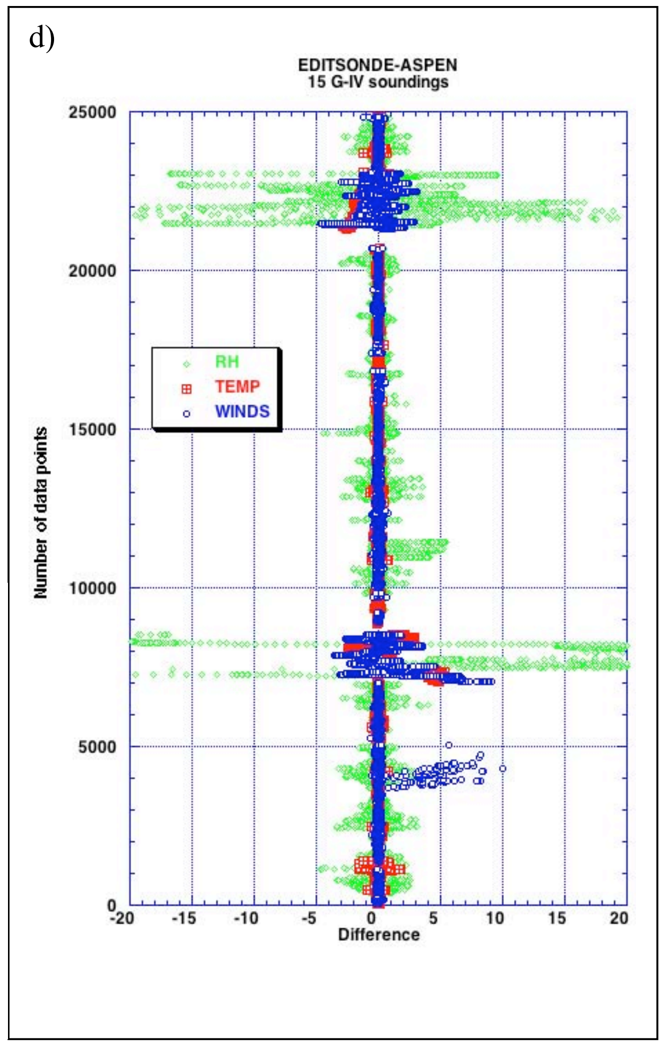


Fig. 4. (a)-(c), Histograms of differences in the output generated from Editsonde and ASPEN from 15 representative G-IV sondes in the TC synoptic environment. (d), Comparisons of all the differences in the data records output from ASPEN and Editsonde from these 15 sondes.