Year-two final report for a Joint Hurricane Testbed Project:

Development of a unified dropsonde quality assurance and visualization capability

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Summary of Accomplishments and Project Status

An operational version of the dropsonde software package, ASPENV3, was distributed to NOAA/AOC and the AFRC at the beginning of the 2011 hurricane season for testing. The NCAR PI, Charlie Martin, traveled to Biloxi to oversee the installation of ASPENV3 on the C-130 aircraft and to provide training to the operators there. Some minor bugs have been identified during the testing and these have been corrected. The software has also been extensively tested by NCAR and by NOAA/HRD. Some minor issues, primarily related to graphics or file handling, have also been identified and corrected by these users. Some minor fixes still need attention.

ASPENV3 has been completely migrated to the NOKIA QT graphics packages and runs on Windows XP and W7, Linux, and Mac OS X operating systems. The software has been thoroughly tested for consistency with the older operational version and with the HRD software suite, Editsonde. Additional capabilities, such as manual editing of the raw data, additional data output formats, and enhanced graphical capabilities have been added to the software suite. These enhancements are described in more detail below.

Three major accomplishments have yet to be fully implemented: 1) Synoptic mapping of the dropsonde observations, 2) Completion and analyses of a validation data set, and 3) a fully up-to-date instruction manual and online training. The synoptic mapping is very close to completion and a description and sample graphical output is given below. We have been acquiring the validation data set from research and reconnaissance missions during the 2011 hurricane season. The analyses package that will be using the validation data is currently being developed. The instruction manual will be completed after the synoptic mapping is implemented. The online training sessions will be built once a complete, stable version of ASPENV3.x is ready for distribution.

While the majority of the timelines outlined in the year-2 proposal have been met, work on the project still remains. The progress has been somewhat slower than anticipated partly because of the complexity of the software components but also because the funding to NCAR was delayed significantly. The cooperative agreement between NOAA and NCAR continues the funding until April 2012, however, so this allows ample time to finish the remaining portions of this project. It is expected that a fully tested, stable, operational version of ASPENV3 will be available for all of the major users during the next several months. Training and documentation will be available before the start of the 2012 hurricane season.

Accomplishments and details

A new operational version of the dropsonde processing software had been developed and built and is called ASPENV3. Using Nokia Qt, multi-platform operation of ASEPNV3 is 100% demonstrated on Windows XP, Windows 7, Linux and Mac OSX and only minor bug fixes still need attention.

A web-based project management toolbox and issue-tracking center using the commercial software, JIRA, has been used extensively for the development of ASPENV3. Here, members of the APENV3 working group, or other invited participants, can easily view and upload issues relating to this project. Project managers can then view any issues, make changes or additions to the software and post the results on the website. This allows for a very efficient mean of tracking and fixing any issues that arise with the software package during the development stages.

ASPENV3 has been extensively evaluated and shown to produce same results as ASPENV2, the current operational version. An examination of output from ASPENV3 and the HRD Editsonde package also shows nearly identical results. The validation data set will further quantify these results and provide a standard for any future modification to the ASPEN code.

ASPENV3 was successfully used operationally in the NSF/NCAR PREDICT campaign from dropsondes released on the NCAR GV aircraft. The software was also used for the NASA GRIP field program for the NASA DC8 dropsondes. The AFRES and NOAA aircraft have been using ASPENV3 when possible in a parallel mode with ASPENV2 during the 2011 hurricane season. The AFRC presented the results of the use of ASPENV3 to NCAR that resulted in several bug fixes or explanations of the results in a NCAR report to the AFRC. NCAR and NOAA/HRD have also been testing and reporting issues that have arisen. Corrections to the software have been done on a nearly continuing basis and the newest versions are available via anonymous ftp.

Batch ASPEN has also been ported to V3 which allows users to quickly process multiple dropsonde profiles from a single or multiple flights. Users have the option to automatically save several types of data and graphical output files.

An additional capability of ASPENV3 that has been implemented is the manual editing of the raw data by selection of text boxes, either for a singular data value or grouping of values. This allows for efficient removal of faulty data that could result in erroneous data being transmitted with the WMO TEMP DROP message. If the user selects data for removal then a flashing red icon appears indicating that the user needs to reprocess the data. Clicking on the flashing icon or clicking on the “recompute” button in the main window can accomplish this. A system of data “flags” assigned to each data point has been incorporated so that users will know what the exact nature of the alterations that have been applied to the data.

Supplementary quality control (QC) upgrades are currently being implemented in ASPENV3. One of the additional capabilities is the plotting of synoptic maps of dropsonde observations at standard atmospheric levels from a series of dropsondes such as those from a single flight. This feature will allow users of dropsonde data to quickly and easily spot faulty data by comparing nearby observations. The synoptic mapping will be fully interactive and will allow the users to pan or zoom the data window and will have detailed geographical overlays built in. The synoptic maps will also reside as a stand-alone program, allowing forecasters or researchers the ability to view the observations from a flight without having to use the raw sonde data. Additional details and an example of the graphics are given in Appendix 2 this report.

ASPENV2 displayed data from only one of the two RH sensors from the dropsonde profile, the one that the aircraft dropsonde software assigned to be used for the QC process. ASPENV3 now has the ability to plot data from both RH sensors and allows the user to determine which one to use in processing. A correction for an RH dry bias will also be implemented when the operator decides that a particular dropsonde needs such a correction. This feature has been on the HRD dropsonde QC software and has been used extensively by trained operators. The use of this feature will require some additional training.

Automatic creation of multiple format ASCII high-resolution data files has been implemented and one of the output types is the HRD file format, used in their archive of processed dropsonde profiles. ASPENV3 can also be used as a file converter so that processed data can be converted from one file type to another. This is especially important for analyzing historical data that may be in a different format that a user is accustomed to.

ASPENV3 now displays “flags” or attributes to each line of data in the “RAW” tab. This allows a user to easily determine why a particular data was changed or omitted from the original raw data. We have been discussing ways to override these flags, thus allowing users to retain data that was omitted during the QC process. This option may be available only in a separate tab for “advanced” users to reduce the possibility of faulty data being inadvertently transmitted via the WMO message.

Some Sample “screen shots” from ASPENV3 are in Appendix 1 which illustrate some of the additional capabilities of the software.

Remaining Work

Finalize the testing, evaluation and debugging of ASPENV3 for operational use on the AFRC and NOAA aircraft. Include the synoptic mapping capabilities to ASPENV3 and provide documentation and training on the use of the new software package to the aircraft dropsonde operators.

Continue work on the development of an automated validation system, which will provide an objective method for comparing processing results between Editsonde and ASPENV3. It will also provide a method for validating software modifications to unified software package as development continues in the future.

Appendix 1: ASPENV3 Sample Graphics

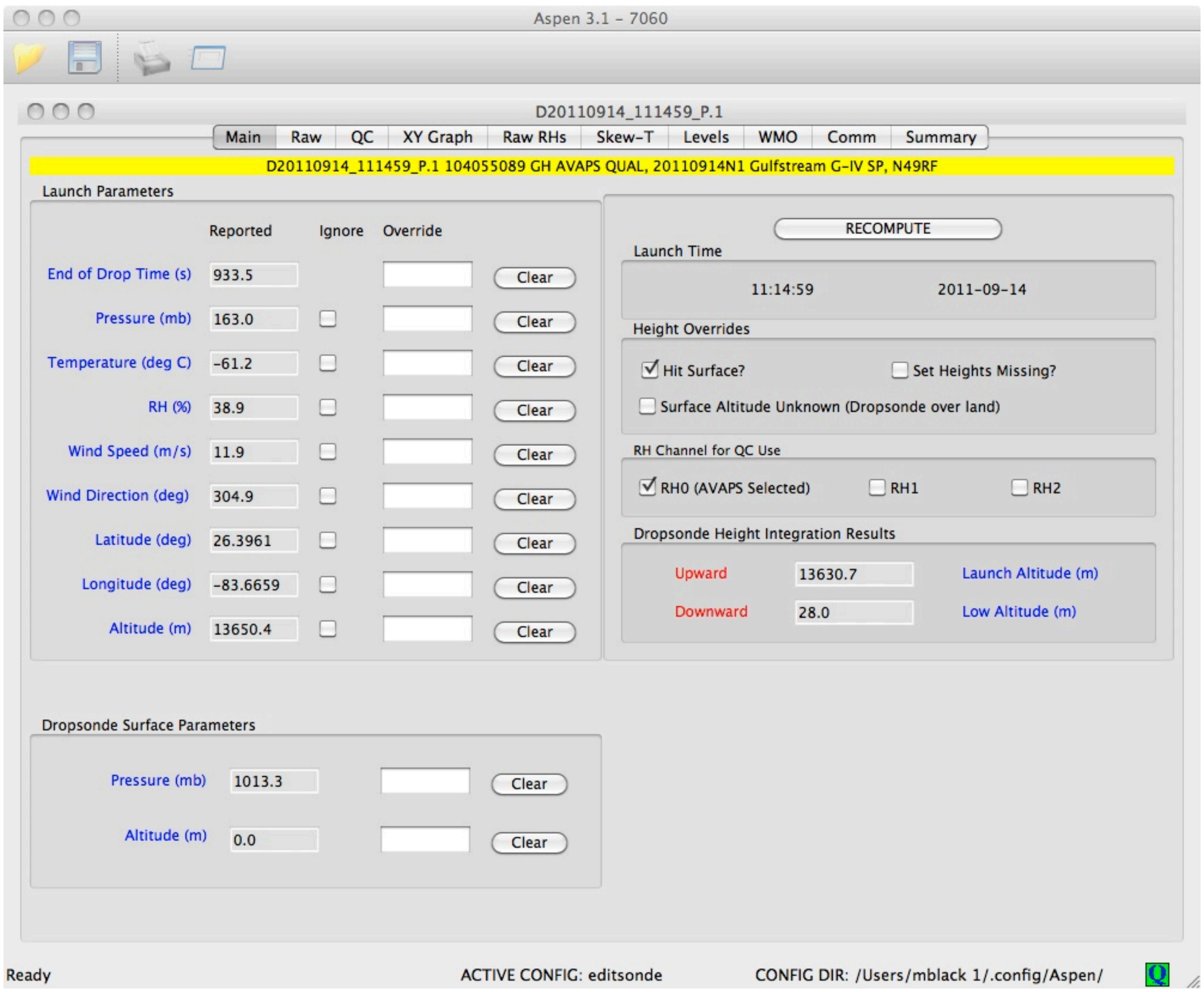
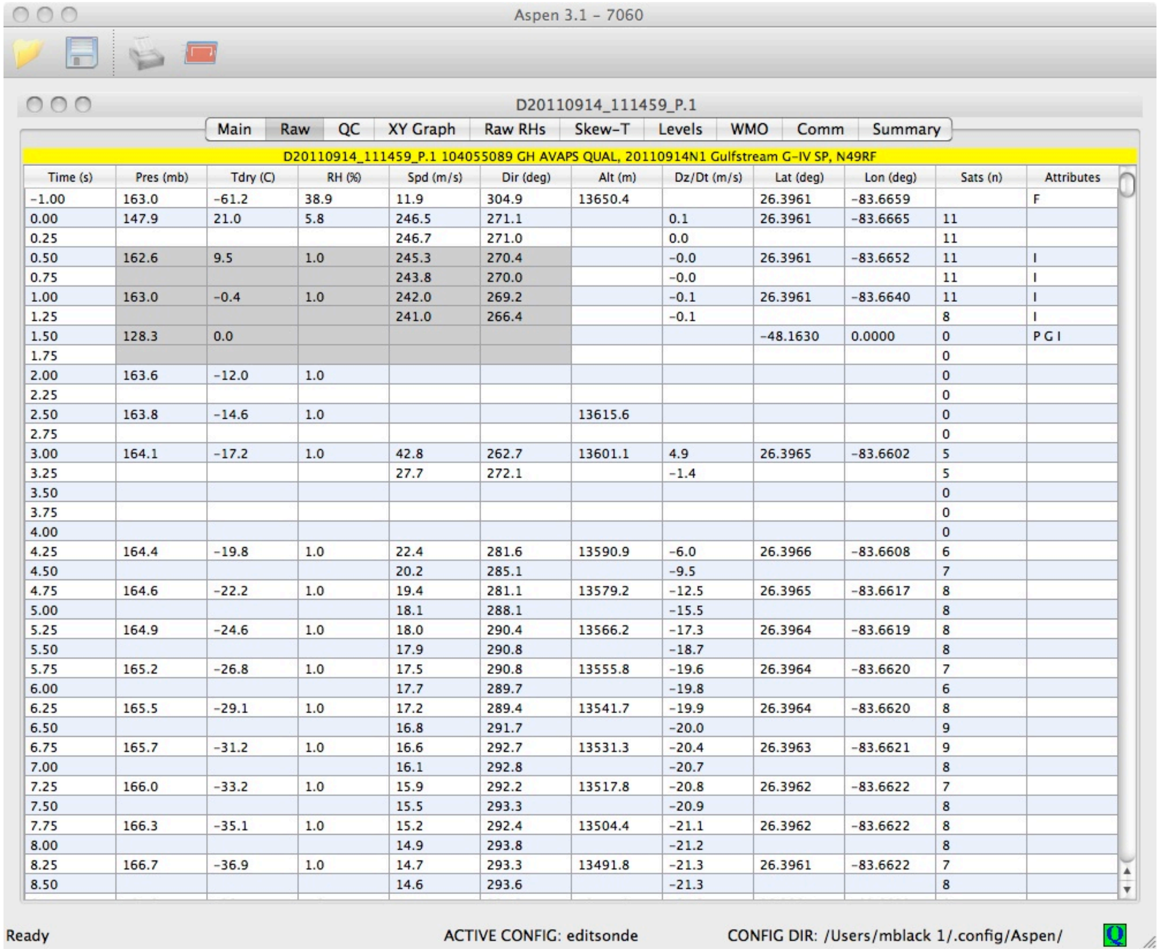


Fig. A1-1: Main display window from ASPENV3 for Mac OSX.



Time (s)	Pres (mb)	Tdry (C)	RH (%)	Spd (m/s)	Dir (deg)	Alt (m)	Dz/Dt (m/s)	Lat (deg)	Lon (deg)	Sats (n)	Attributes
-1.00	163.0	-61.2	38.9	11.9	304.9	13650.4		26.3961	-83.6659		F
0.00	147.9	21.0	5.8	246.5	271.1		0.1	26.3961	-83.6665	11	
0.25				246.7	271.0		0.0			11	
0.50	162.6	9.5	1.0	245.3	270.4		-0.0	26.3961	-83.6652	11	I
0.75				243.8	270.0		-0.0			11	I
1.00	163.0	-0.4	1.0	242.0	269.2		-0.1	26.3961	-83.6640	11	I
1.25				241.0	266.4		-0.1			8	I
1.50	128.3	0.0						-48.1630	0.0000	0	P G I
1.75										0	
2.00	163.6	-12.0	1.0							0	
2.25										0	
2.50	163.8	-14.6	1.0			13615.6				0	
2.75										0	
3.00	164.1	-17.2	1.0	42.8	262.7	13601.1	4.9	26.3965	-83.6602	5	
3.25				27.7	272.1		-1.4			5	
3.50										0	
3.75										0	
4.00										0	
4.25	164.4	-19.8	1.0	22.4	281.6	13590.9	-6.0	26.3966	-83.6608	6	
4.50				20.2	285.1		-9.5			7	
4.75	164.6	-22.2	1.0	19.4	281.1	13579.2	-12.5	26.3965	-83.6617	8	
5.00				18.1	288.1		-15.5			8	
5.25	164.9	-24.6	1.0	18.0	290.4	13566.2	-17.3	26.3964	-83.6619	8	
5.50				17.9	290.8		-18.7			8	
5.75	165.2	-26.8	1.0	17.5	290.8	13555.8	-19.6	26.3964	-83.6620	7	
6.00				17.7	289.7		-19.8			6	
6.25	165.5	-29.1	1.0	17.2	289.4	13541.7	-19.9	26.3964	-83.6620	8	
6.50				16.8	291.7		-20.0			9	
6.75	165.7	-31.2	1.0	16.6	292.7	13531.3	-20.4	26.3963	-83.6621	9	
7.00				16.1	292.8		-20.7			8	
7.25	166.0	-33.2	1.0	15.9	292.2	13517.8	-20.8	26.3962	-83.6622	7	
7.50				15.5	293.3		-20.9			8	
7.75	166.3	-35.1	1.0	15.2	292.4	13504.4	-21.1	26.3962	-83.6622	8	
8.00				14.9	293.8		-21.2			8	
8.25	166.7	-36.9	1.0	14.7	293.3	13491.8	-21.3	26.3961	-83.6622	7	
8.50				14.6	293.6		-21.3			8	

Fig. A1-2: Raw data window from ASPENV3 showing new attributes column, selection of data to ignore, and red "recompute" button.

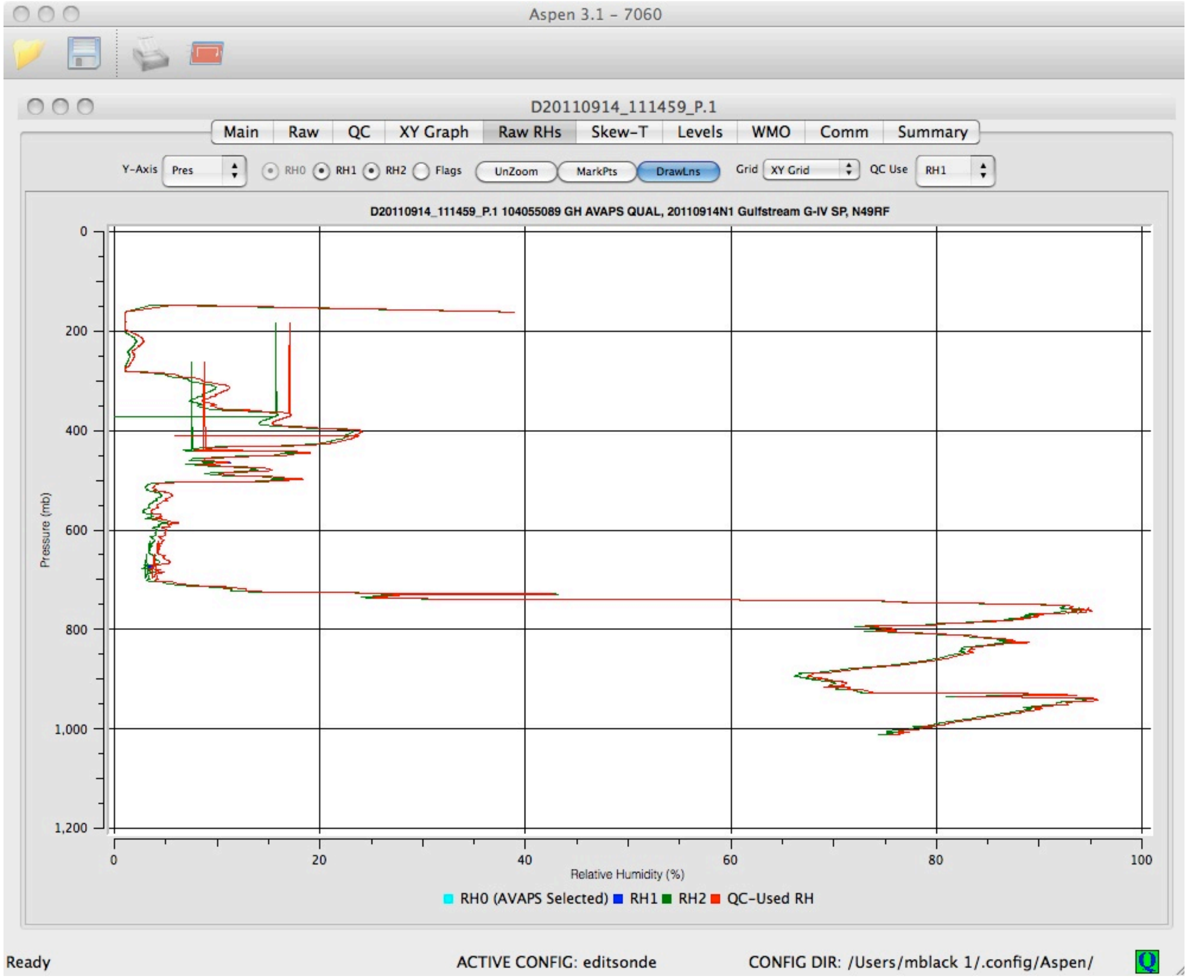


Fig. A1-3: Display of the two raw RH sensor data from ASPENV3 with capability to select either sensor for use in the QC output.

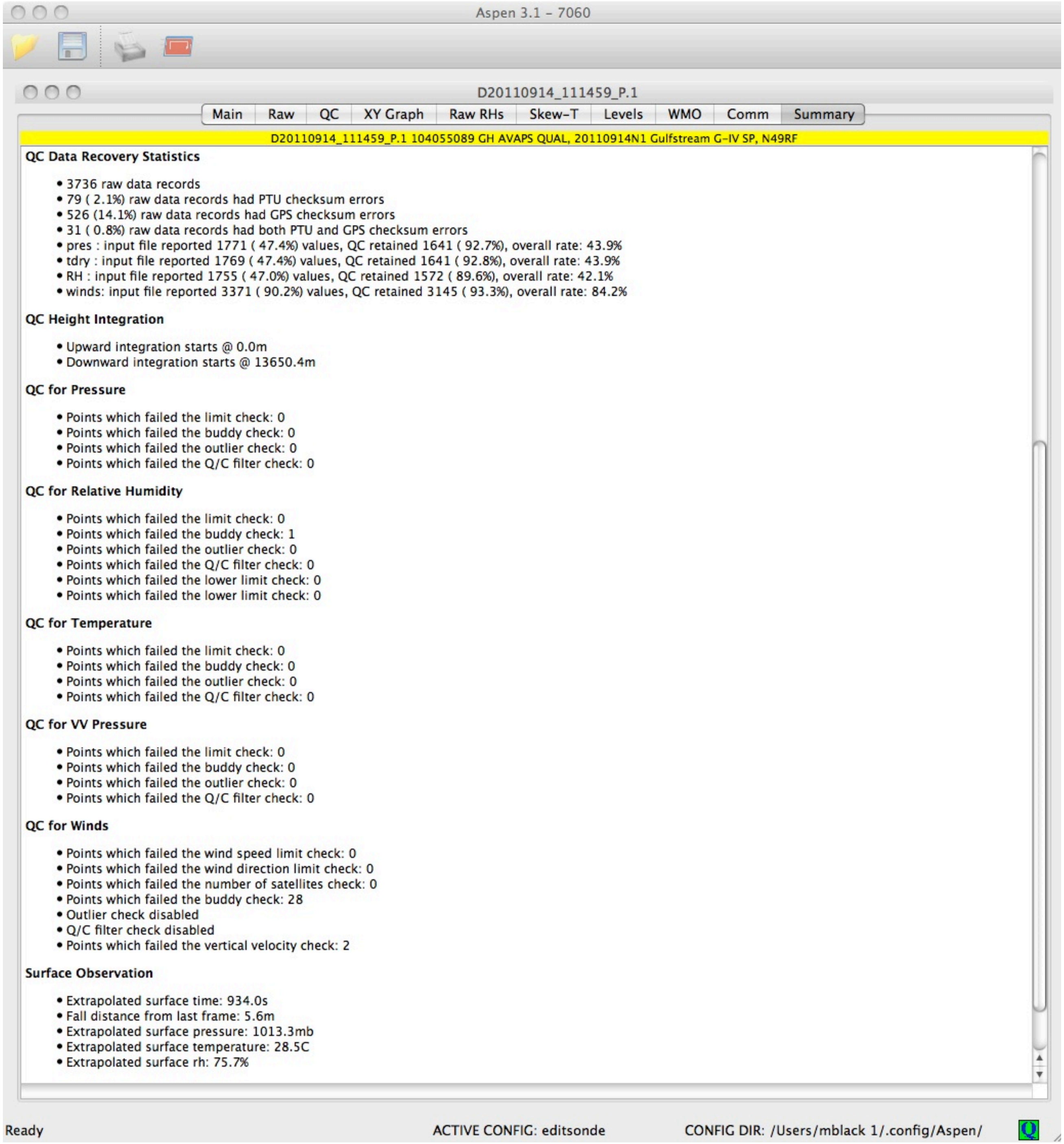


Fig. A1-4: Statistical summary window from ASPENV3 indicating the results of the QC processes.

Appendix 2: ASPENV3 Synoptic Map Display

The ASPENV3 synoptic map display is approximately half completed.

A Qt map component, with a station model component, has been implemented and tested in a standalone application. This component allows for zooming and roaming (panning). Item selection (i.e. choosing a particular station model) will be easily added.

An embedded geometric database was implemented to provide the geopolitical boundaries to the map component. The database is built from the open source *sqlite* and *spatialite* packages. Arbitrary shapefiles can be processed to create a distributable database file that is navigated by the embedded database. A 10 MB file can contain suitable geopolitical information at an adequate resolution for ASPENV3. This makes standalone rendering, without Internet access to data sources, possible.

The remaining work involves integrating the map component into ASPENV3 user interface, and creating a method for indexing multiple soundings, so that they can be chosen for display on the map. It is possible that the *sqlite* database will provide the required functionality to store and navigate a large number of soundings.

Note that *sqlite* is considered by some to be the world's most common database, due to the fact that it is used in a large fraction of the cell phones in the world.

Below are two examples of the type of graphical capabilities of synoptic map display.

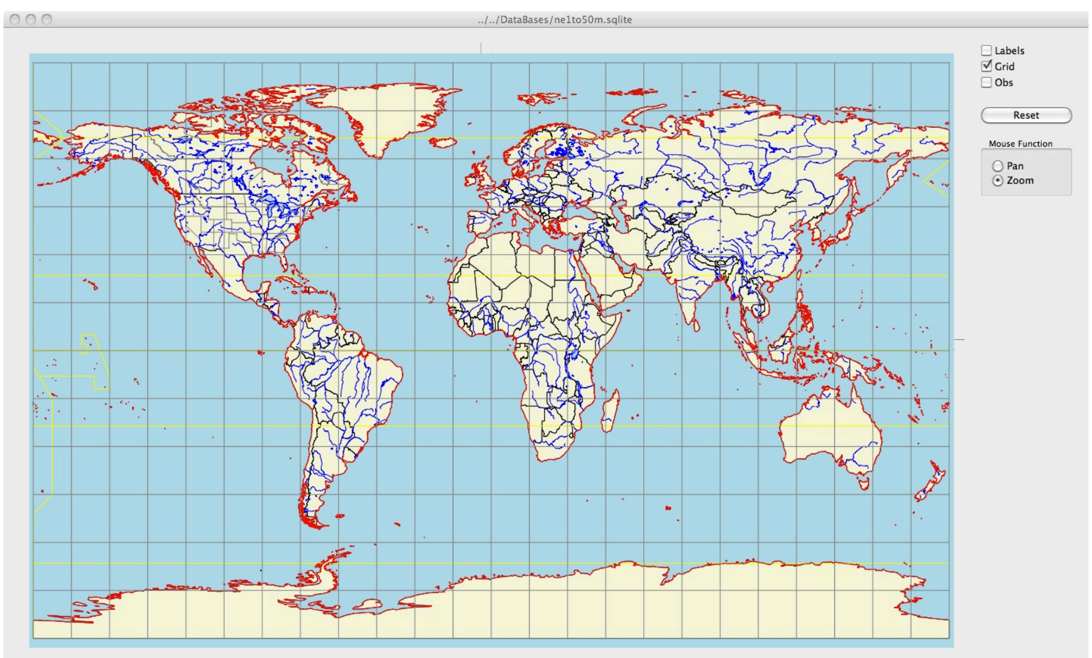


Fig. A2-1: Example of the geographical data base to use as a background for the synoptic weather observations.

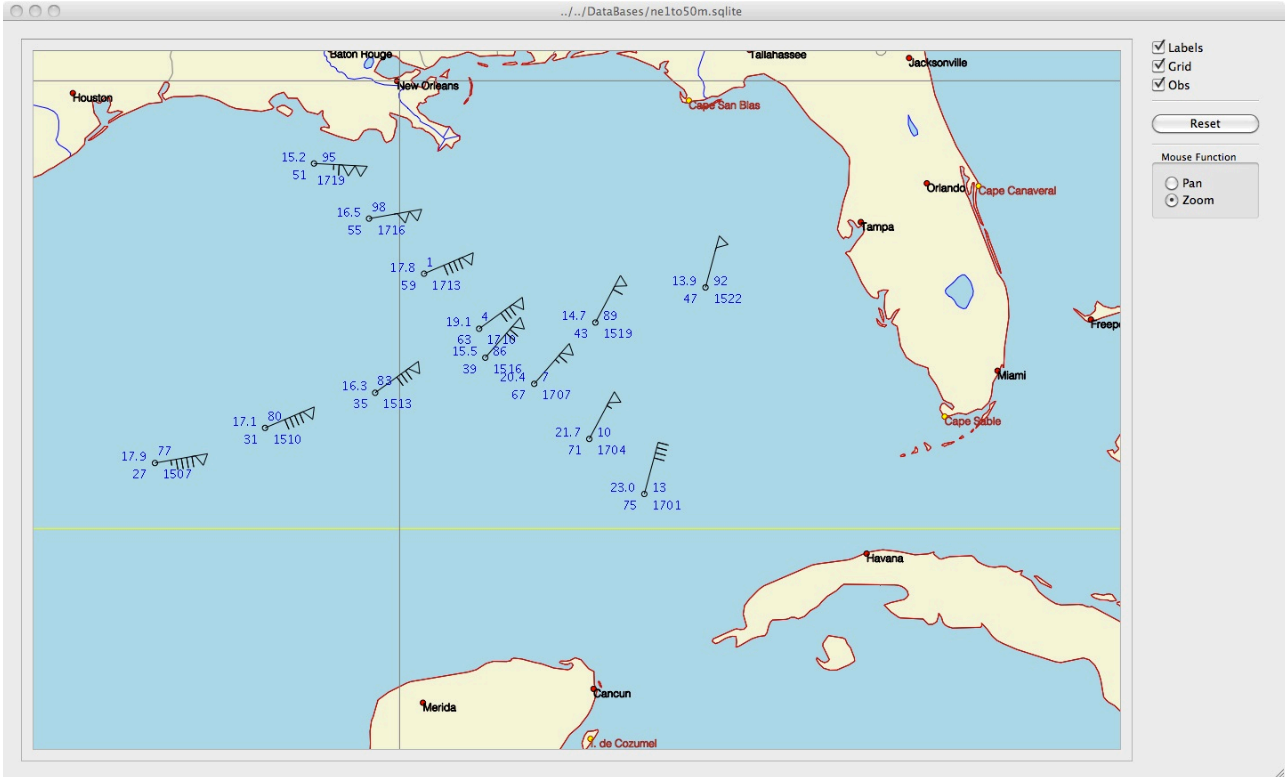


Fig. A2-2: Simulated synoptic plotting of dropsonde observations overlaid on a geographical map of the Gulf of Mexico region.

Appendix 3: ASPENV3 Validation Framework

Validation requirements for the ASPENV3 software must achieve two goals. For the first goal, it must be shown to essentially reproduce the processing results of the HRD Editsonde software, for dropsonde measurements. Where there are discrepancies, it must be shown that the ASPEN results are the desired ones. Once ASPENV3 is able to create results that meet these criteria, this output (i.e. files and graphics) will be preserved as a baseline for future comparison. Analysis of upsonde profiles will also be added to the baseline at this time.

The second goal is that future modifications to ASPENV3 will result in software that produces results that accurately match the baseline. A failure may indicate a software error needing correction. However, it may be that the new results are addressing a latent software bug or a required change, in which the vetted results from the new version will replace the current baseline.

Thus, once an acceptable comparison with Editsonde has been demonstrated, output from future versions of ASPENV3 will be compared to the original baseline, or a modified baseline created from ASPENV3 output. No further direct Editsonde comparisons will be performed.

A mechanism for documenting and preserving the history of the baseline will be required. The standard revision control system will be a good fit for this.

It is not simple to establish that an adequate match between ASPEN and Editsonde output has been successfully met. The same will be true for comparison of two ASPENV3 versions. What is required is that the two programs are creating essentially the same final profile, from a measurement perspective. Subtle difference in the processing algorithms will create sounding profiles that have small numerical differences, but are within the tolerances of the instrument and the algorithms. A combination of comparisons will be applied to deal with this situation:

- The standard levels from decoded TEMP messages will be automatically compared. The computed standard levels should match very closely between two programs.
- The decoded TEMP messages for both programs will be plotted and compared visually to insure that they essentially portray the same sounding.
- It may be possible to develop an objective automated technique that interpolates data at a pressure level in one TEMP message from the other TEMP message, and vice versa. If the differences are within a prescribed delta, then the TEMP message profiles have an adequate match.
- The visual and interpolated comparisons described above will also be applied to the Q/C data products.
- Statistical measures, such as min/max and standard deviation, will be compared between the two program outputs.

These analyses will require that a consistent set of ASPENV3 quality control parameters be maintained over time.

It may be useful to create a standardized validation report for each software release, containing the validation products and comments from the human analyst.

The input data for processing will consist of a set of dropsonde and upsonde files selected to demonstrate different characteristics. These characteristics may include: the sounding platform, weather environment and measurement anomalies. A representative selection of nominal soundings will also be included in the validation set. All files will have accompanying notes describing the conditions that they are representing in the set. For the Editsonde comparison, Editsonde will be used to process the dropsonde files, with as little operator intervention as possible. The FRD and TEMP output will be preserved for the baseline, along with description of any operator manipulation required.

In addition to comparison of output data products, the ASPENV3 user interface must be validated for each software release. A checklist of user actions will be followed and the program behavior verified against expected results.