Ronald Brown IMET Data Quality Control Report: July 2005 – November 2005

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1.0 Introduction

This report summarizes the quality of the surface meteorological data collected by the research vessel (R/V) *Ronald Brown* (identifier: WTEC) IMET system during the 7 cruises beginning 11 July 2005 and ending 25 November 2005. The data were provided to the Florida State University – Research Vessel Surface Meteorological Data Center (RVSMDC) on compact disk by Jonathan Shannahoff. The ASCII files were converted to standard RVSMDC netCDF format. The data were preprocessed using an automated screening program, which automatically adds quality control flags to the data, highlighting potential problems. Next, the data are run through our statistical Spike and Stair-Step Indicator (SASSI), which adds flags for spikes and steps in the data. Finally, the Data Quality Evaluator (DQE) reviewed the data and current flags, whereby flags were added, removed, or modified according to the judgment of the DQE and other RVSMDC personnel. Details of the quality control procedures can be found in Smith et al. (1996). The data quality control report summarizes the flags for the *Ronald Brown* IMET surface meteorological data, including those added by the preprocessor, SASSI, and the DQE.

2.0 Sensor Information

The *Ronald Brown* data were received as one-minute averages. Observations for the following variables were provided:

Time	(time)
Latitude	(lat)
Longitude	(lon)
Platform Heading	(PL_HD)
Platform Course	(PL_CRS)
Platform Speed Over Ground	(PL_SPD)
IMET Platform-Relative Wind Direction (14.12 m)	(PL_WDIR)
IMET Platform-Relative Wind Speed (14.12 m)	(PL_WSPD)
Earth-Relative Wind Direction (14.12 m)	(DIR)
Earth-Relative Wind Speed (14.12 m)	(SPD)
IMET Platform-Relative Wind Direction (25.5 m)	(PL_WDIR2)
IMET Platform-Relative Wind Speed (25.5 m)	(PL_WSPD2)
Earth-Relative Wind Direction 2 (25.5 m)	(DIR2)
Earth-Relative Wind Speed 2 (25.5 m)	(SPD2)
Atmospheric Pressure (15.56 m)	(P)
Air Temperature (12.98 m)	(T)
Sea Temperature (5.6 m)	(TS)
Relative Humidity (12.98 m)	(RH)
Short-wave Atmospheric Radiation (10.01 m)	(RAD)
Long-wave Atmospheric Radiation (10.01 m)	(RAD2)
Precipitation	(PRECIP)

3.0 Results

3.1.0 Statistical Information

A total of 3,145,422 values were evaluated with 97,213 flags added by the preprocessor, SASSI, and the DQE resulting in 3.09% of the data being flagged for the 5 months of cruises of the *Ronald Brown* from July though November 2005. A breakdown of each of the cruises is provided in Table 1.

Table 1: Statistical 2005 Cruise Information

Cruise Identifier*	Cruise Dates	Number of Records	Number of Values	Number of Flags	Percent Flagged
05E	7/11 – 7/15	5,912	124,152	4,784	3.85
05F	7/17 – 8/3	23,968	503,328	16,666	3.31
05G	8/10 – 9/3	35,090	736,890	20,269	2.75
05H	9/6 – 9/9	3,974	83,454	1,812	2.17
05I	9/11 – 9/24	17,663	370,923	18,432	4.97
05J	10/4 – 10/20	22,667	476,007	5,899	1.24
05K	10/27 – 11/25	40,508	850,668	29,351	3.45

* Assigned by RVSMDC to ease identification

3.1.1 Quality Control Information

The quality of the data for the latter part of 2005 collected on the R/V *Ronald Brown* varied between cruises and parameters. However, the data was of good quality, 1 – 5% flagged, for all of the cruises evaluated in this data set. When all of the cruises were combined, the total amount of data flagged was 3.09%. This total is similar to the last set of *Ronald Brown* data evaluated for the period of May 2004 – March 2005, which had 2.85% of the data having flags applied. The earth-relative wind direction at 14.12m ranged from good (1-5% flagged) to poor (>10% flagged) quality, although only the 0E and 05I cruises were of poor quality with 11.89% of the data flagged in each cruise. The earth-relative wind speed at 14.12m ranged from good to fair quality with the 05I cruise having the highest percentage of speed data flagged (8.29%). The earth-relative wind direction at 25.5m also ranged from good to fair quality. Again, the 05I cruise had the greatest amount of data flagged with 9.12%. The quality of the earth-relative wind speed at 25.5m ranged from good to poor where the 05I cruise was the highest flagged by far at 11.81%. The atmospheric pressure data quality was excellent (0-1%) during the 05E, 05F, 05H, and 05J cruises and was of good quality during the remaining cruises. The air temperature was typically of good quality although the 05E and 05J cruises were of excellent quality. The quality of the sea temperature data was mostly excellent although there were issues with the sensor during the 05E cruise resulting in poor quality data; the 05F cruise was of good quality. The relative humidity data quality varied from excellent to poor although as a whole, the data was of fair quality with 7.91 % flagged. The short-wave atmospheric radiation typically recorded negative values during the night. This is expected due to the calibration of the instrument not being tuned for such low values of short-wave radiation, so the large number of flags does not reflect the quality of the data collected during daylight hours. The long-wave atmospheric radiation was of excellent quality for all of the cruises with the exception of the 05H cruise which had good quality data with only 1.23% of the data flagged. The low number of flags applied to the precipitation data is the result of the recognition of problems with either a leak, evaporation, or spilling of the precipitation in the collection container resulting in the elimination of the data. There were also periods where the sensor recorded negative values of accumulated precipitation. A discussion of the flagged and removed variables follows. Some of the data may be of particular interest due to the proximity of the vessel to hurricanes Rita and Ophelia during the record setting Atlantic season.

NOTE: SASSI only applied to scalar variables. These variables include the earth relative wind speeds, sea temperature, air temperature, atmospheric pressure, and relative humidity.

Table 2: Number and Percentage of Data Flagged for Each Variable

Variable	B	E	G	H	I	J	K	S	U	V	X	Y	Total # of Flags	Total % of Data Flagged
TIME													0	0.00
LAT													0	0.00
LON													0	0.00
PL_HD								2					2	0.00*
PL_CRS								1					1	0.00*
PL_SPD								1					1	0.00*
PL_WDIR								1,461					1,461	0.98
PL_WSPD								235					235	0.16
DIR		1,573			2		6,440	829					8,844	5.90
SPD		147	5		4		4,984	198	1,007	136	78	34	6,593	4.40
PL_WDIR2								985					985	0.66
PL_WSPD2								155					155	0.10
DIR2		2,783			2		4,808	708					8,301	5.54
SPD2		356	11	2	4		4,698	252	632	91	39	14	6,099	4.07
P				2	4		3,106	1	10				3,123	2.09
T					4		4,085	1	20	6	84	23	4,223	2.82
TS	311					697	83	1	319	58	202	144	1,815	1.21
RH	644				4		1,979	13	5,637	574	1,626	1,375	11,852	7.91
RAD	43,058					47							43,105	28.78
RAD2					1		49	1					51	0.03
PRECIP								367					367	0.25
Total Number of Flags	44,013	4,859	16	4	25	744	30,232	5,211	7,625	865	2,029	1,590	97,213	
Percentage of All Variables Flagged	1.40	0.15	0.00*	0.00*	0.00*	0.02	0.96	0.17	0.24	0.03	0.06	0.05		

* Percentages < 0.01%
**Grey shading indicates the given flags are not applied to highlighted variables.

3.1.2 Deleted Data

The DQE determined that some of the 2005 *Ronald Brown* IMET data were unusable due to extensive highly suspect data. As a result these data were removed from the final quality controlled data set.

The precipitation data from all of the cruises were removed after visual quality control due to the lack of confidence in the data collected. The R.M. Young self-siphoning rain gauge leaked nearly everyday and recorded negative values of accumulated precipitation. For example, 2 September the rain gauge leaked over 2.5 mm to a value of -0.6 mm of total precipitation.

3.1.3 Missing Data

There was missing data during every cruise although only one of the cruises had a substantial gap, the 05K. There were 809 minutes of data missing for all variables during the 05K, the majority of which, 780 observations, occurred 30 October as the vessel was off the coast of Peru. In this example, all of the data was inexplicably missing through 12:59 UTC. The amount of data missing for the 05E cruise was 2 minutes, 05F and 05I each had 10 minutes missing, 05G was lacking 13 minutes, only 1 observation was lost during the 05H, and the 05J cruise was missing 9 records. All of the missing data, with the exception of the example discussed, was just a random minute or so in all of the variables. This was determined using the daily statistics generated by the countflags routine, revealing the missing data when there were less than 1440 one-minute observations in a given day. The exceptions to this were the first and last day of cruises as the vessel was still in port. The cause of the missing data is unknown but may be the result of instrument system maintenance, rebooting of the data logger or time rounding issues.

3.2.0 Variable Flagging

3.2.1 Stair Stepping

Stair stepping of the navigation variables is an inherent property of these variables due to the motion of the vessel. Stair stepping of the meteorological variables in response to a change in the vessel's motion, course, speed or heading, is often an indicator of questionable meteorological data values. Meteorological data in the absence of flow distortion, (See section 3.2.2), should not reflect the motion of the vessel. Therefore, such values received the cautionary K-flag. Some of the steps were caught by SASSI, the statistics based prescreener, and received the X-flag, usually in conjunction with the other flags used by the program. There were 11,244 U, X, and Y-flags applied to the data by SASSI. Nearly everyday of all of the cruises had a suspect step in one of the variables' time series. There were steps in every cruise evaluated. This resulted in the application of 30,232 K-flags, although not all of them were for stair stepping; some were for prolonged spikes (> 5 minutes). Some of the steps were not flagged, as there were no visible links in other variables' time series to the steps; i.e., changes in the platform heading and course related to steps in the true wind direction, steps in the earth relative wind speed corresponding to steps in the platform speed, steps in the air temperature or atmospheric pressure due to changes in platform-relative wind speed. Note: some of the steps in the true winds have had E-flags applied by the prescreener prior to visual inspection for failing the true winds recalculation test. The earth-relative wind direction and speed from both anemometers, the atmospheric pressure, air and sea temperature, the relative humidity, and the long-wave atmospheric radiation were the meteorological variables that had steps in the data related to the motion of the vessel.

The earth-relative wind direction from the anemometer at 14.12m had steps during 58 days of the cruises resulting in 6,440 K-flags. An example of the earth-relative wind direction stepping took place 13 August during the 05G cruise. In this case the winds were holding fairly steady at about 220° as the vessel's heading and course shifted 135° resulting in the winds stepping about 40°. Once the vessel returned to its prior track, the winds also returned to their previous trend.

The earth-relative wind speed at 14.12m had steps during 43 days of all of the cruises totaling 4,984 K-flags and 1,255 SASSI flags. During the 05I cruise the true wind speed had many steps with the motion of the vessel on 22 September as the vessel was in between the Bahamas and Florida. In this case, the vessel would cruise towards the southwest or west-southwest at about 3-5m/s and then drift for a while towards the north-northwest less than 2m/s. The steps in the speed and direction of the vessel instigated steps in the true wind speed of about 3 m/s, from about 7m/s to 10m/s and back down repeatedly.

The earth-relative wind direction at 25.5m had steps resulting from the motion of the vessel during 49 days of the cruises. The steps resulted in the application of 4,808 K-flags. 29 October had a step in the 25.5m earth-relative wind direction of about 35° from 115° to 150°. The step in the wind direction coincided with a shift in both the heading and course of the vessel. The heading went from about 290° to about 125° for nearly 35 minutes and then returned to the previous heading of 290°. The course in this example was also at about 290° when it shifted to about 100° before returning to 290°.

The true wind speed from the anemometer at 25.5m had steps during 42 days of the cruises considered in which 4,698 K-flags and 685 SASSI flags were applied. 22 November there were 2 steps in the data due to steps in the vessel speed. In both cases, the speed of the vessel went from about 7m/s to 1m/s. The wind speed dropped 7m/s to about 2m/s from 9m/s for the first case and to just over 5m/s, also from 9m/s for the second case.

There were 29 days that the atmospheric pressure had steps. The steps were likely due to the flow over the barometer varying with changes in the orientation of the vessel, resulting in changes in the platform-relative wind speed. Some of the steps were not flagged, as changes (or lack thereof) in other variables' time series, usually the platform-relative wind speed, did not look to be related to the step. Another reason that steps may not have been flagged is the fact that they were only around one to two tenths of a millibar. The small steps in magnitude correspond to changes in the platform-relative wind speed. There were many steps in the atmospheric pressure 22 September as the vessel was heading to Florida from the Bahamas in a zigzag pattern. The pressure steps were typically about 0.5mb and occurred with steps in the navigation data as well as the platform winds. There were also steps in the true winds for the example given. A total of 3,106 K flags and 10 SASSI flags were applied to the pressure data.

The air temperature had steps in the data related to a ventilation issue and will be discussed in section 3.2.4.

The relative humidity experienced steps that were typically related to the ventilation issue with the air temperature. This will be discussed in 3.2.4. There were, however, steps in only the relative humidity that occurred on 3 occasions: 15 August, 9 September, and 25 November. On 9 September, the vessel was just off the coast of South Carolina approaching Charleston. The relative humidity was steadily rising from about 80% to just over 82% when the vessel turned and the humidity suspiciously dropped to 77%.

The sea temperature rose 0.4°C in the east equatorial Pacific southwest of the Galapagos Islands on 23 November. The step does not seem to be linked to ship motion. The vessel may have encountered a warm eddy and be valid although the cautionary K-flags were applied. There were 83 K-flags applied to the sea temperature.

There was also a step in the long-wave atmospheric radiation that took place on 6 September as the vessel was leaving Cape Cod, MA. The long-wave radiation unexpectedly dropped about 5W/m^2 , out of the trend of the data resulting in 49 K-flags. The short-wave radiation also stepped dramatically and was J-flagged at the same time. The cause of the steps is unknown.

3.2.2 Flow Distortion

Flow distortion was suspected to be a problem during the *Ronald Brown* cruises from 2005 detailed in this report. Flow distortion is the result of the wind flowing over and around the cargo on the deck and superstructure of the vessel relative to the location of the instrument sensors. Since the cargo varies from cruise to cruise, it is often very difficult to identify the source of the flow distortion problem. Some flow distortion is inevitable. With two sets of anemometers, occurrences of flow distortion can be identified by the differences in the platform-relative wind speeds and directions between the 2 different anemometers, and also the differences between the calculated true wind speeds and directions between the anemometers. The *Ronald Brown* has multiple wind sensors, although at differing heights, enabling easier identification of flow distortion problems. Flow distortion often results in a high degree of uncertainty in the winds.

Nearly everyday had some degree of flow distortion taking place, although most were minor.

There was flow distortion affecting the earth-relative wind direction early in the day on 27 August. In this example, the anemometer at 14.12m was recording wind out of the north-northeast and the 25.5m anemometer was recording wind from the north-northwest.

The earth relative wind direction was also suspect due to flow distortion 6 September at about 18:10 UTC. In this case the 14.12m anemometer increased from 100° to values between 150° and 200°. The other anemometer at 25.5m was recording values of about 100° +/-15° when its values decreased to values below 80°.

The earth-relative wind speed also experienced flow distortion 6 September, although at a different time, 20:38UTC. Here, both anemometers were steady at about 6m/s when the 25.5m anemometer decreased to values of 2-4m/s. These differences are also visible in the platform-relative wind speed time series.

Improved documentation of the sensors, their locations, and their surrounding environment (i.e., digital photos of sensor sites and current metadata) will improve our understanding of flow distortion effects on individual sensors.

3.2.3 Winds

The IMET wind data for the cruises of 2005 evaluated from the R/V *Ronald Brown* continued the trend of being of substantially better quality than the winds collected in earlier years. Historical QuikScat data was compared to the vessel data during visual inspection of the R/V data. This method of comparison may have reduced the number of flags applied to the data, resulting in the lower percentage of data flagged. When all of the cruises' wind data were considered as a whole, the quality was better than that of the last set of cruises (evaluated at COAPS) from May 2004 – March 2005 for the *Ronald Brown*.

Overall, the earth-relative wind direction from the anemometer at 14.12m had 5.90% of the data flagged compared to 9.35% for the cruises of late 2004 and early 2005. The true wind speed from this anemometer had only 4.40% flagged whereas the previous data had 9.09%. Obviously, the data from the 14.12m anemometer continues to improve for reasons unknown, although the comparison to the QuikScat data may play a role in the reduction of the number of flags applied.

The anemometer at 25.5m also continues to improve, as there was a reduction in the amount of data flagged for both the true wind speed and direction from this anemometer. The earth-relative wind direction only had 5.54% of data flagged, a 4.36% reduction from the last data set. The true-wind speed went from 7.24% flagged for the last set of cruises to 4.07% for the current cruises' data.

The true wind direction data from the 14.12m anemometer was of fair quality for the 05K cruise (6.76%), poor for the 05E and 05I cruises (11.89% for both) and good quality for the remaining 4 cruises. The earth-relative wind speed for the same anemometer was of excellent quality during the 05H cruise (0.65%); fair quality during the 05E (5.82%), 05I (8.29%), and 05K (5.71%) cruises; and good for the 05F (3.35%), 05G (3.54%), and 05J(1.78%) cruises.

The quality of the earth-relative wind direction at the 25.5m anemometer was good for the 05G (3.41%), 05H (2.92%), and 05J (2.18%) cruises. Fair quality data was recorded for the remaining 4 cruises for the direction. The 25.5m wind speed quality was good, and had less than 3% of data flagged, for all of the cruises with the exception of the 05K (fair – 5.14%) and 05I (poor-11.81%).

The platform-relative wind data was only flagged for acceleration spikes and will be further discussed in section 3.2.13.

3.2.4 Ventilation

An insufficiently ventilated thermometer can experience steep rises in temperature in a relatively short period of time when the platform-relative wind speeds are light or when the flow over the instrument is blocked. The ventilation issue can also affect the relative humidity values. If the amount of moisture in the atmosphere remains the same and the temperature increased due to poor ventilation, the relative humidity will decrease if it is derived from temperature data. However, not all of occasions of the ventilation problems are reflected in the relative humidity data since the relative humidity has its own independent sensor with a different time constant. The main pattern used to identify a ventilation problem is a relative maximum in air temperature, or a minimum in relative humidity or dew point during a period of relative minimum in platform-relative wind speed. Note: when the relative humidity is derived from temperature sensor data, the relative humidity could decrease if the air temperature rose due to ventilation issues. Ventilation problems are more pronounced when the atmospheric radiation is at or near the daily maximum. Ventilation issues, when identifiable were K-flagged by the DQE or had U, V, X, or Y flags added by SASSI to identify the steps. Not all of the values that were K-flagged in the air temperature were the result of ventilation issues. There were cases where there were no identifiable causes of temperature change.

There were 38 days in which the temperature stepped due to ventilation issues, 16 of which also had steps in the relative humidity. The steps in the air temperature were typically between 0.5°C and 1.7°C while the steps in the relative humidity were typically on the order of 5%. On 27 July the air temperature rose 3°C from 24°C as the platform-relative wind speed dropped about 3m/s to values between 0and 1m/s. 29 October, during the 05K cruise, the platform-relative wind speed fell ~2m/s resulting in a temperature increase of 1°C and a decrease in relative humidity of 5-7%.

There was a situation, 2 November, in which the platform-relative wind speed at 25.5m increased from 3 to 6m/s and the air temperature fell 0.2°C. The air temperature values were K-flagged.

3.2.5 Navigation Data

The navigation variables experienced few problems during the cruises. The first instance was the application of L-flags by the prescreener to the latitude and longitude as the vessel was exiting the Intercoastal waterway of Charleston, SC on 11 July. These flags were removed by the DQE. Another instance was during the 05G cruise on 11 August. In this example the heading and course of the platform both shift about 10°, out of the trend of the data receiving spikes.

3.2.6 B Flags

The B-flag is applied to those values falling outside of a realistic, acceptable range by the preprocessor. On rare cases, the bounds flag highlights extreme, natural events. There were B-flags added to the sea temperature (311), relative humidity (644), and the short-wave atmospheric radiation (43,058).

All of the sea temperature flags were added on 11 July as the temperature recorded was just above 33°C in and after exiting the Intercoastal waterway of South Carolina until it dramatically fell to 29.6°C in one minute of the coast.

The relative humidity flags were all applied 18 June during the night as the vessel was pulling off the coast of Cape Cod. The values that were flagged were all slightly over 100%, a feasible but rare situation.

The remaining B-flags were applied to the sort-wave radiation. They were applied to values less than 0W/m^2. There were B-flags added to nearly every day of every cruise. The 05-J cruise had significantly fewer flags applied than the rest of the cruises, only 6.15% of the data compared to 24-44% for the other cruises. [B-flags generally applied to nocturnal short-wave radiation values < 0W/m^2. These occur because the sensor is not tuned to resolve very low to zero short-wave radiation values.]

3.2.7 E Flags

E-flags are added by the preprocessor to calculated earth-relative wind values that fail the true winds recalculation test. To fail, the values must have more than a 20° difference in the direction and the speed difference must be more than 2.5m/s in order to have the E-flag applied. There were a total of 4,859 E-flags applied. The anemometer at 14.12m had 1,573 flags applied to the earth-relative wind direction and 147 to the speed. The 25.5m anemometer had 2,783 flags added to the earth-relative wind direction and 356 to the speed. There were 849 E-flags removed or modified during the quality control process. Many of the E-flags were applied to acceleration spikes that are discussed in section 3.2.12.

3.2.8 G Flags

There were G-flags assigned by the preprocessor to values greater than four standard deviations from the climatological mean (da Silva, et al., 1994). The flagged values were typically just greater than the four standard deviation limit and may represent extreme, realistic values. There were a total of 16 G-flags applied to the earth relative wind speed data. The 14.12m anemometer received 5 and the 25.5m true wind speed had 11. On 12 September, the 25.5m earth relative wind speed had 5 G-flags applied to the data as it was southwest of Hurricane Ophelia off the east coast of Florida. The flagged values were between 20 and 25m/s. There were also 5 added on 19 September as the vessel was near the northern Bahamas and Tropical Storm Rita passed to the south and the wind speed was about 15m/s. There were also 3 flags added on 20 September, likely due to a squall from Rita, to true wind speeds of 20m/s at 14.12m and 1 to the 25.5m wind speed of 25m/s.

3.2.9 H Flags

The H-flag is used to identify discontinuities, large and sudden shifts in the data time series. These occur for several reasons, such as electrical interference, although a return of the data values to their original trend may not take place. There were a total of 4 H-flags added to the data. There were 2 applied to the 25.5m earth-relative wind speed and 2 added to the atmospheric pressure. 21 July was when the discontinuity in the wind speed took place as the wind suddenly dropped from 7m/s to 4m/s without a link to any noticeable cause. The step in the pressure took place off the coast of Peru/Chile 12 October as the pressure suddenly went from 1018.4mb to 1019.7mb, again without physical support from the other meteorological variables.

3.2.10 I Flags

The I-flag represents an interesting feature or event that has taken place in the environment and was recorded by the instruments and identifiable in the data. These can be used when identifying fronts and tropical cyclones for example. There were a total of 25 I-flags applied by the DQE. The I flags were applied to the earth-relative wind direction (2) and speed (4) at 14.12m, the earth-relative wind direction (2) and speed (4) at 25.5m, the atmospheric pressure (4), the air temperature (4), the relative humidity (4) and the long-wave atmospheric radiation (1).

I-flags were applied 13 July as the vessel passed through a trof off the Carolina coast. The flags were added to the both true wind directions as they both veered from about

250°, through all 360°, and returned to their original values after about 5 hours. Both true wind speeds recorded maximum values of about 20m/s compared to the prior and post trends of 3m/s, the air temperature dropped from 28.5°C to a minimum of 21.5°C, the relative humidity reached a minimum of 76% after the passage before reaching a maximum of 98%, and finally the pressure reached a minimum of 1013.8mb. 13mm of rain also fell although the data were not flagged as leaks had been taking place with the sensor.

23 August was another day with flags added for an interesting feature, as the vessel was located in the Central Atlantic at about 307°E, 36.1°N. This event seemed to be a squall as the pressure drop was 0.8mb and short-lived. The wind directions were noisy at the time and since no major shift took place, no flags were added. The wind speeds did increase about 11m/s to 18m/s. The temperature fell from 27°C to 22.4°C and the relative humidity increased from about 80% to nearly 95%. A small increase in long-wave radiation and 4mm of precipitation fell although neither had flags applied.

There was another trof passage 1 September as the vessel was a few hundred miles off the New England coast. There was a wind shift of about 45° +/-5° in each of the true wind direction variables. Both speed values increased about 9m/s to 12m/s and the pressure reached a minimum of 1006.9mb after having reached 1012mb earlier in the day. The temperature and relative humidity briefly changed; the air temperature fell 2° to 24.5°C for roughly an hour and the relative humidity increased 7% to 96% before returning to about 88%. Finally, the long-wave radiation reached a maximum of 450W/m^2 after having only been at about 400W/m^2 throughout much of the day.

Finally, a squall from Hurricane Rita encountered the vessel at about 5UTC 20 September off the coast of east coast of the Bahamas. There were maxima in the true wind speed data after increasing about 7m/s to over 20m/s. The pressure fell a millibar in 3 minutes during the rain event in which the air temperature fell 5°C and the relative humidity rose 15%, resulting in the application of the I-flags.

3.2.11 J Flags

The J-flag is added to values that are clearly incorrect. There were J-flags added to the sea temperature (697) and the long-wave atmospheric radiation (47). The sea temperature had J-flagged data on 12 July during the 05E cruise off the Carolina coast. In this case, the sea temperature increased very steadily from 28.0°C to 30.0°C in just less than 11 hours and then fell back to previous values. This seems feasible although the rate of increase was so constant it was suspect.

The J-flags were applied to the short-wave radiation 6 September as the vessel was leaving Cape Cod. The short-wave radiation was steadily falling until about 15:50UTC when the value dropped to under 100W/m^2 in one minute and remained nearly constant until 20:37UTC. This was out of the trend of the other data and lacking support for the shift, resulted in the application of the J-flags. The long-wave atmospheric radiation also dropped 5W/m^2 during this period, although it had K-flags applied to the step as its values varied.

3.2.12 S Flags, Data Spikes

Isolated data spikes often occur with automated data and can be caused by various factors such as electrical interference. Acceleration spikes are also common when data is collected on moving vessels (Smith, 1999). These often appear as ‘noisy’ data. Spikes occurred in most of the variables in this data set. These points were assigned the S-flag when they were visually identified using VIDAT. There were also spikes flagged with V-flags added by the automated QC program SASSI. Spike flags (S) were added during visual inspection to the platform heading (2), platform course (1), the platform-speed over water (1) and all of the meteorological variables, with the exception of the short-wave atmospheric radiation. SASSI applied spike flags (V) to the earth-relative wind speed from both anemometers, the air and sea temperature, and the relative humidity.

The spike flag applied to the platform speed took place 20 July as the vessel increased its speed 2m/s out of the trend of the other data.

The spikes in the heading and course both occurred 11 August. Each variable was not varying much throughout the day when both values spiked about 10° out of trend with the other data.

The atmospheric pressure spiked approximately 0.4mb in 1 minute out of the trend of the data on 22 September. There was no support in the other meteorological variables’ data to support the spike.

The sea temperature had a spike 23 July in the central Atlantic. The sea temperature was highly variable around the time of the spike of the temperature of ~0.7°C. There were additional data collected about an hour later with suspect flags from SASSI applied to rapid fluctuations of the same magnitude.

There were many spike flags added to nearly all of the meteorological variables on 22 August. The long-wave radiation had a spike from 395 to 440W/m^2 in one minute. The relative humidity spiked from 79% to 83%, also in one minute. The precipitation data suspiciously spiked from about 28.5mm to over 31mm on three separate occasions. And finally, the air temperature had a spike of 0.6°C as the temperature went from 26.4°C to 27.0°C in one minute. There were also acceleration spikes in all of the wind data.

The majority of the spike flags applied were due to acceleration spikes in the wind data, platform- and earth-relative. Acceleration spikes are due to the movement of the vessel and therefore the instrument. They are often found as the vessel is changing speed and/or direction (Smith et al., 1999). They are visible as spikes where the time series levels off, yielding continued motion, i.e. turning, speeding up or slowing down. The main variables with acceleration spikes are the platform-relative wind speed and direction, as well as the true winds, albeit to a lesser degree. Acceleration spikes propagate from the measured platform-relative winds to the calculated earth-relative winds since the platform-relative winds are used in their calculation. Nearly everyday had acceleration spikes in the wind data. Acceleration spikes were sometimes flagged with E-flags by the preprocessor.

26 July had many spike flags applied to the wind direction data. For example, the platform-relative wind direction at 14.12m was at about 70° and then it unexpectedly started recording values throughout the entire range of 0-360°. The 25.5m platform-relative wind direction was also recording values of about 70° when it started to record values near 300° and others near 20°. The true wind direction at 14.12m had acceleration spikes as the wind was blowing from about 170° and then values began to be recorded from nearly every direction. The 25.5m earth-relative wind direction had acceleration spikes, although not nearly as many as the 14.12m anemometer. Most of the 25.5m true wind direction spikes were recorded at about 0° and 350°.

There were acceleration spikes applied to the earth-relative wind speed from both anemometers on 31 July. In this case the 14.12m speed had an instance of increasing a few meters per second and then 2 instances of decreasing a few meters per second. The higher anemometer only had 2 spikes, both of which the wind speed fell a few m/s unexpectedly.

3.2.13 SASSI Flags

SASSI, an automated statistical QC program did well with most of the data from the *Ronald Brown*. The automated program may have over-flagged the relative humidity data as many of the flags were removed during visual quality control. SASSI flags were also removed from the sea temperature, earth-relative wind speeds, and air temperature. Some of the flags applied may have been modified during subsequent steps in the quality control process. SASSI did well with the true wind speed data. 9 November is an example of SASSI flagging spikes in the 25.5m true wind speed data. Here the wind was fairly constant at about 4m/s, however there are several spikes between 10 and 15m/s that have the V-flag correctly applied be SASSI. 1 August is an example of SASSI applying spikes (V) and suspect (U) flags to the true wind speed at 14.12m. The data become very noisy about 21UTC and have many SASSI flags applied.

3.3.0 Final Comments

3.3.1 Winds and Overall Quality

Overall, the data collected during the cruises of the *Ronald Brown* for the middle and late parts of 2005 were of similar quality to the last set of cruises only having 3.09% of the data having been flagged for the current cruises and 2.85% for the previous ones. The true wind data continued to improve since the last cruises. The true wind direction data from both anemometers was of fair quality, each having just over 5% of the data flagged, and the wind speed data were of good quality as less than 5% of the data were flagged for both anemometers. Flow distortion and acceleration spikes were the main factors reducing the quality of the wind data. The 05H cruise had the highest quality earth-relative wind data while the 05I cruise had the worst. Historical QuikScat data was compared to the wind data which may have prevented the application of flags, resulting in a lower percentage of flagged data. The short-wave radiation data had the most flags added due to recording negative values at night. This is likely due to the tuning of the instrument sensor.

3.3.2 Insufficient Data

In parts of each of the cruises, the DQE would like to note that some of the data might have been left unflagged due to insufficient meteorological backing because of the lack of data. In some cases there was not enough evidence to say whether or not certain questionable data should have been flagged.

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