Brief Comparison of the Effects of Pre-editing in MBMax Before Running Data through HYCUBE

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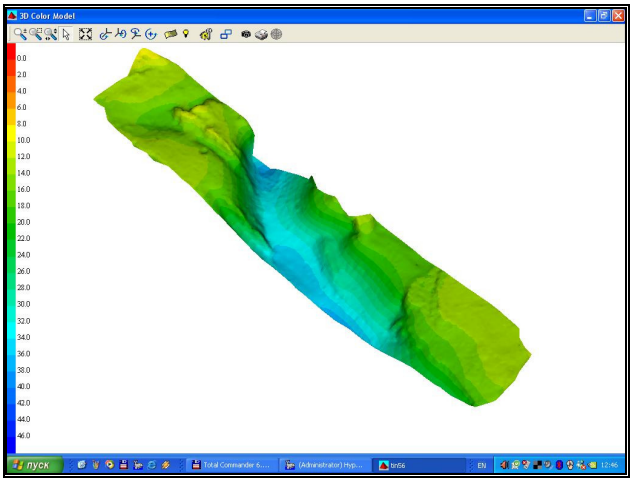
The CUBE algorithm, developed by Dr. Brian Calder of CCOM-UNH, can be used to speed up the editing multibeam data. Beginning in HYPACK® 6.2a, it became a standard feature of the HYSWEEP® module and is called HYCUBE. In order to load multibeam data collected in HYSWEEP® SURVEY into HYCUBE, you first have to run their data through the MBMAX multibeam editing program. This correlates position and MRU data with each ping and computes the X-Y-Z result of each beam.

The question that has been asked is, "**How much pre-editing in MBMAX should I do before running the data through HYCUBE?**"

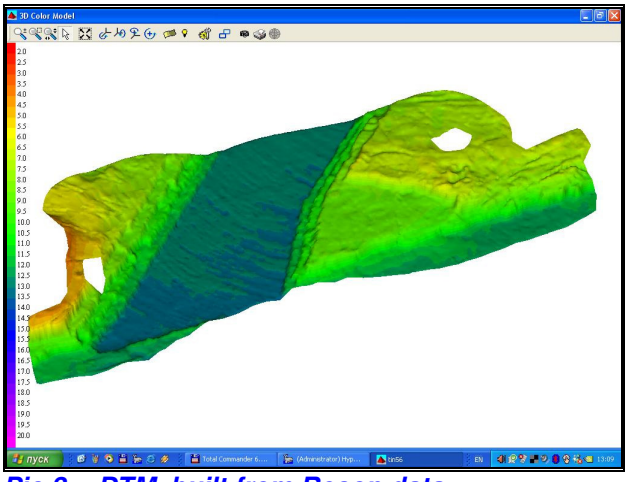
To investigate this question I took a look at three data sets.

The first data set was collected with GeoAcoustics' GEOSWATH system on a VERY rough day. The GEOSWATH multibeam is an interferometric system.



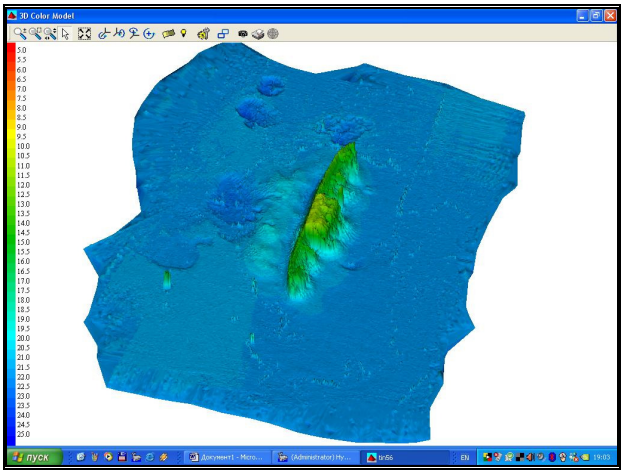
Pic.1 DTM, built from Geoswath data

The second set of data was collected with the Reson SeaBat8101 multibeam. It uses phase and amplitude bottom detection algorithm.



Pic.2 DTM, built from Reson data

The third set of data was collected with the same Reson system, but features a wreck.



Pic.3 DTM of the wreck, built from Reson data.

In all three cases the bottom is uneven. The first two data sets are typical of channel surveys while the last one is typical of a wreck investigation.

The idea of my study was to determine how my final XYZ data set would vary by applying different levels of editing in MBMAX before taking the data into HYCUBE. My three editing cases were:

Case 1: No editing in MBMAX. (Let's call it the 'No-Edit' data.) I just viewed the data in Phase 1 of MBMAX and saved them as HS2 files, which I then loaded in HYCUBE.

Case 2: Minimal Editing in MBMAX (Beam Angle, Min and Max filters, Savitsky - Golley and Overhang and Undercut Topography filters) before saving the data in HS2 files. (Let's call it 'Min-Edit' data.)

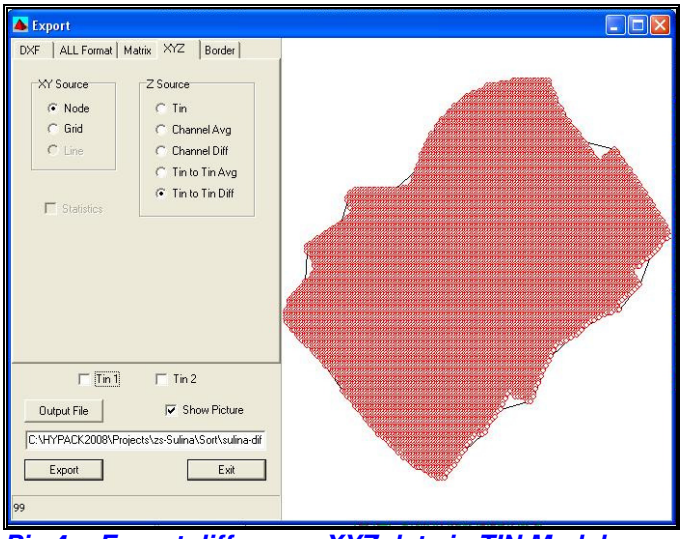
Case 3: Very precise editing in MBMAX, using all filters in phases 2 and 3. (Let's call it 'Max-Edit' data.)

In HYCUBE, I used the new "Minimize Uncertainty" function (HYPACK® 2008 edition) for all of the cases. This function selects the depth estimate with the minimum uncertainty at each node and does a very nice job of eliminating any residual spikes. I then saved XYZ file where the Z-value was the CUBE Depth Estimate for the node.

I then used HYPACK®'s TIN MODEL program to take the difference between the resulting XYZ data sets. For example, I would load the 'No-Edit' and 'Min-Edit' XYZ files into TIN MODEL and output an XYZ difference file where the Z-value represents the difference between the input Z-values.

Having these difference XYZ files, I used a very useful “XYZ Distribution” program, created by Pat, to display the distribution of differences and calculate statistics for the files (average difference, minimum and maximum differences and the standard deviation of the differences).

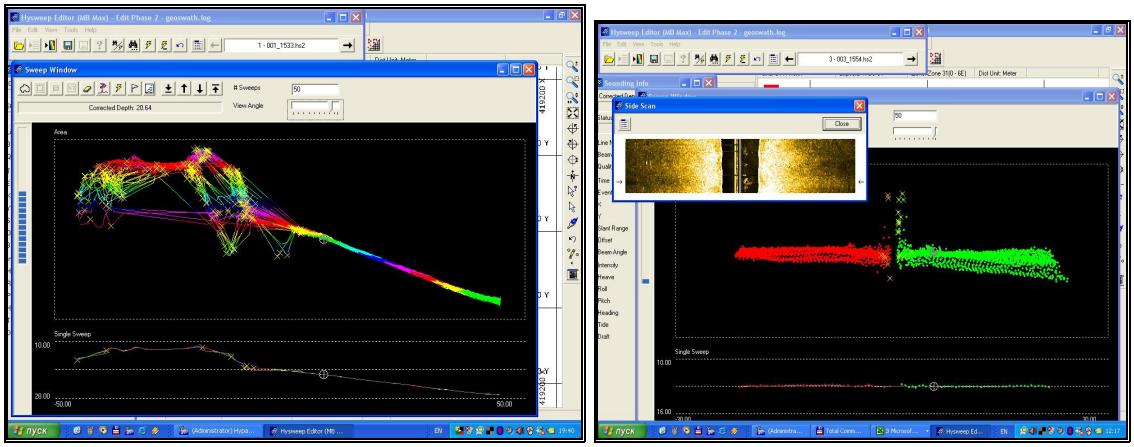
Now let’s see the results.



Pic.4 Export difference XYZ data in TIN Model

Geoswath Data

This was a nasty data set that was collected on an extremely rough day without any pre-filters used during logging. Please note that it is not representative of normal Geoswath data that is normally pre-filtered. With beam angles greater than 70 degrees, data sets like these are real hell for hydrographers – take a look at the pictures below!

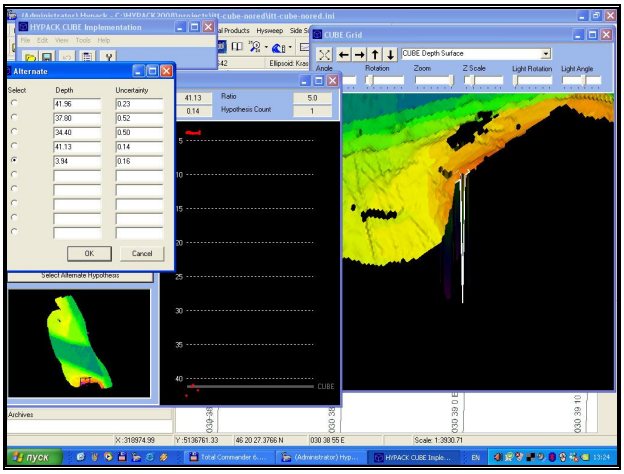


Pic.5 Examples of the Geoswath data in MB Max, phase 2

With this data set, I could not use the “Savitsky - Golay” filter. There were a lot of outliers in the middle of the sweeps (see the picture). For Case 3 (Max-Edit) I removed all those outliers in the middle along with all other spikes.

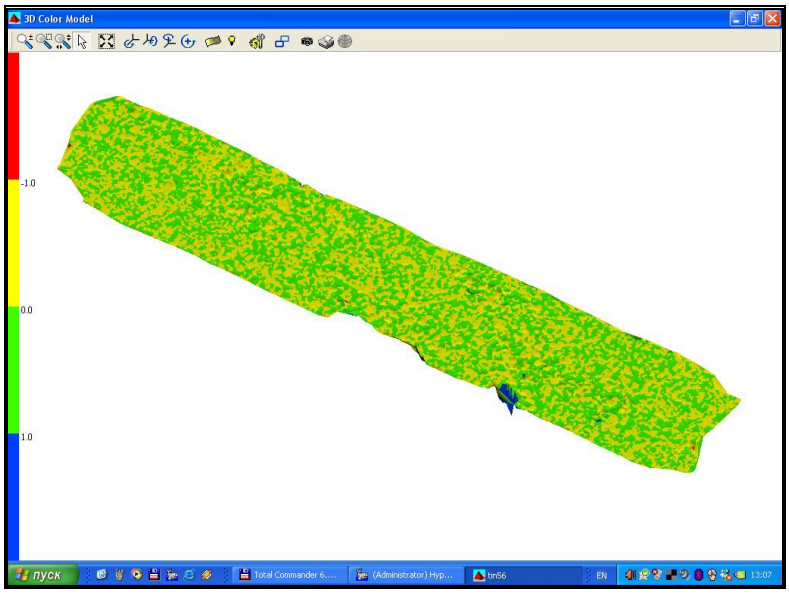
There is no Geoswath echosounder in the list of multibeam systems in HYCUBE, so I selected the “Not Listed” option. In parameters I set GPS and MRU offsets and, as an error model, I selected “Simple Model Based on IHO S44”.

After the files had been loaded into HYCUBE, I used the “Minimize Uncertainty” option to select the Depth Estimate with the minimum uncertainty to be selected at each node. I also spent some time selecting alternative hypotheses for some nodes with really big spikes.

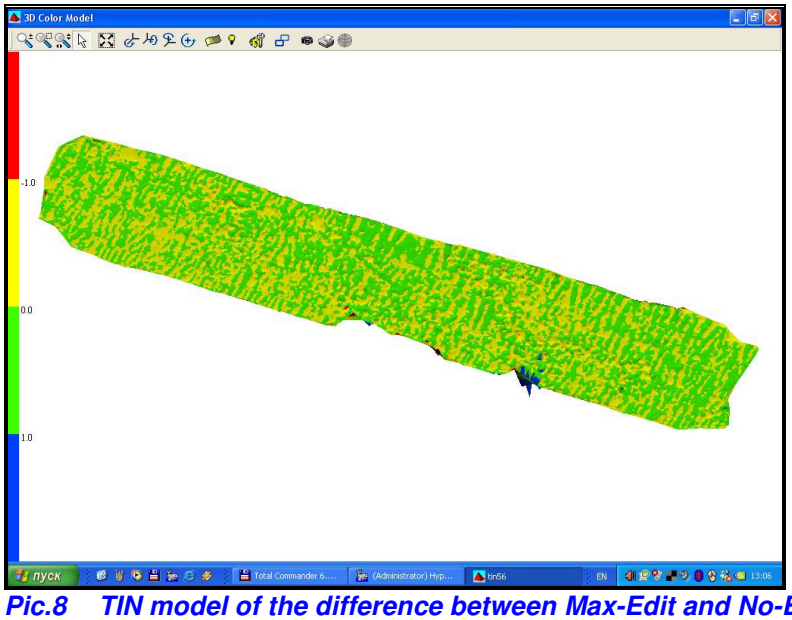


Pic.6 Selection of an alternative hypothesis

Now let’s take a look at the pictures below.

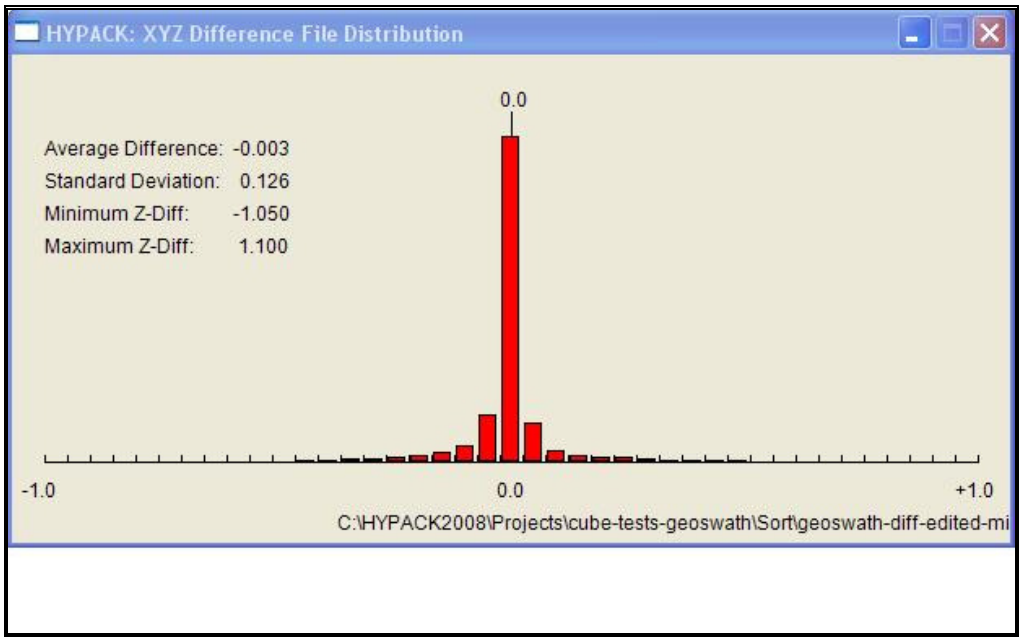


Pic.7 TIN model of the differences between Max-Edit and Min-Edit data (Geoswath)

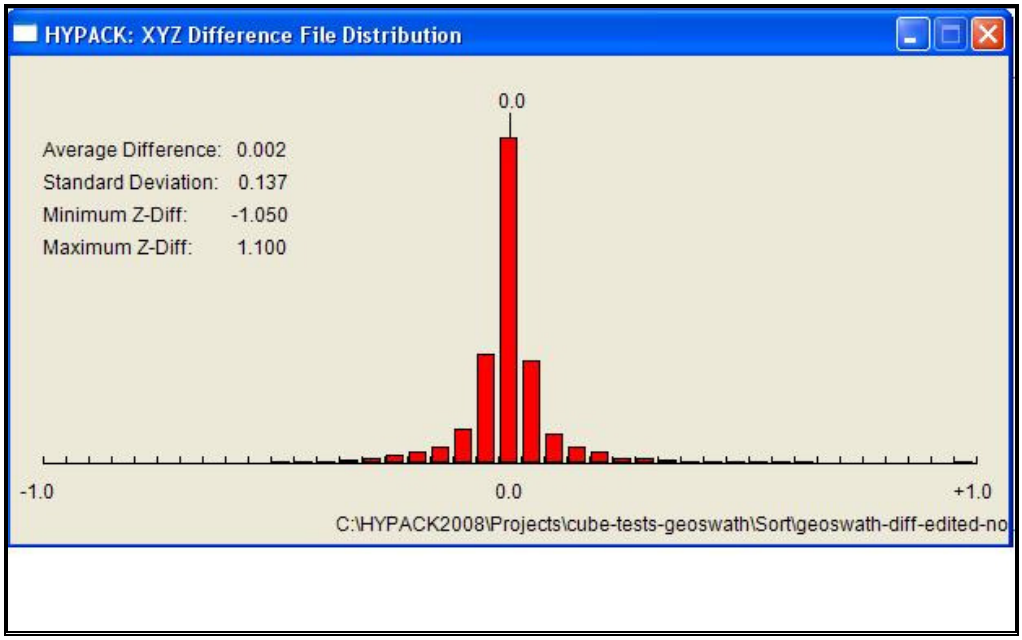


Pic.8 TIN model of the difference between Max-Edit and No-Edit data (Geoswath)

From these pictures, we see that the biggest outliers are on the edge of the surveyed area, but generally the difference cannot be seen with the eye.



Pic.9 Differences distribution between Max-Edit and Min-Edit files (Geoswath study).



Pic.10 Differences distribution between Max-Edit and No-Edit files (Geoswath study)

For analysis, I removed the biggest outliers (more than 1.1m) inside of XYZ Distribution program.

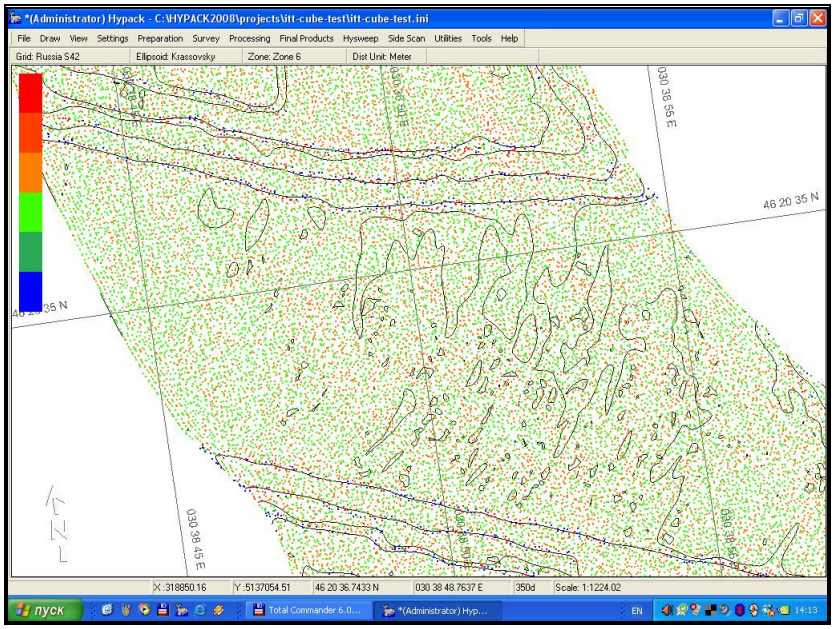
From the above histograms we can make following conclusions.

- The average difference in both cases is extremely small (only 2 and 3 millimeters).
- The standard deviation for both cases is almost the same and quite large (12 and 14cm respectively). Perhaps users with noisy data should spend a little time editing the data in MBMAX before bringing it into HYCUBE.

Reson SeaBat8101 Data

In this study, the overall quality of raw data is much higher. This is a 150° system. According to the Beam Angle Test, it must be reduced until 130°. As in the previous case, I created three XYZ files. For Case 2 (Min-Edit), I used Min – Max filters, cut beam angles to 65° from both sides and used Savitsky – Golay and Undercut Topography filters.

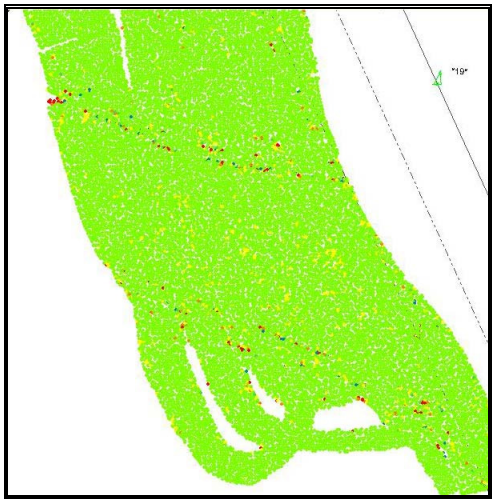
There is a Reson SeaBat8101 in the HYCUBE list. I entered GPS and MRU offsets and selected "Full MBES Model for every sounding" as an error model. After creating difference models in TIN MODEL, we see that the largest differences between the XYZ data sets are on the slopes of the channel.



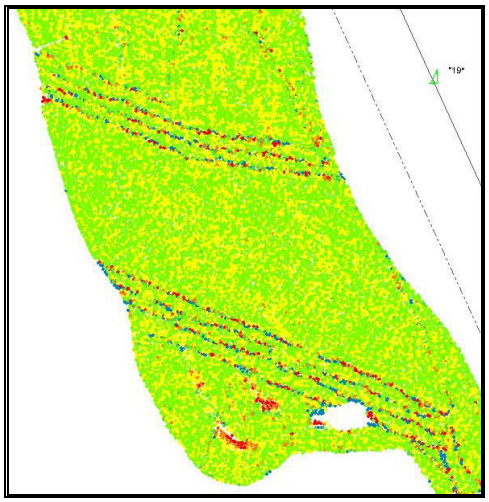
In picture 11, the black colored lines are contour lines, and you see that the biggest differences are around channel slopes.

Pic.11 Error distribution over the channel. Max-Edit vs No-Edit data.

Pictures 12a and 12b show TIN Difference models between the Max-Edit and Min-Edit data (12a) and between Max-Edit and No-Edit data respectively. Here you can see that overall difference is much smaller if you will use minimum editing in MBMAX before loading data into HYCUBE.



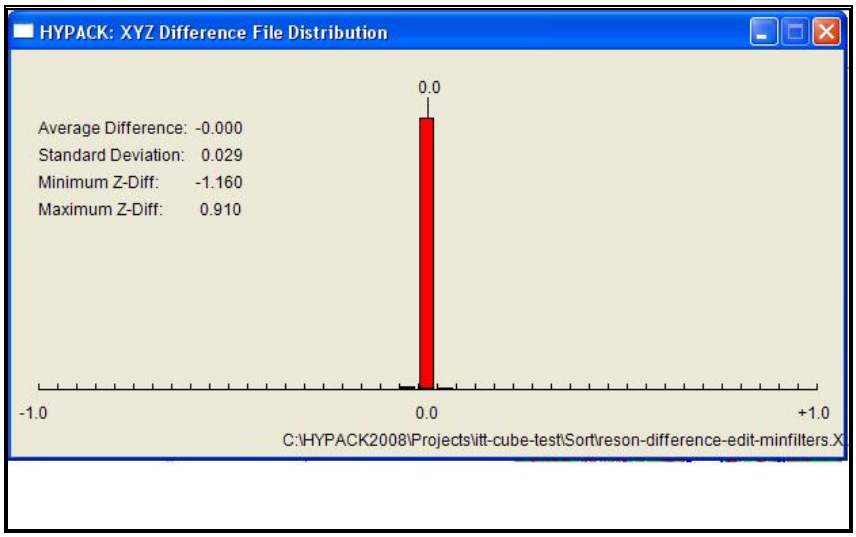
Pic.12a Difference model for Min-Edit data.



Pic.12b Difference model for No-Edit data

Again, illustrated in picture 12b, it can be seen that the biggest differences are on the channel slopes.

Let's see the distribution histogram for Reson data below.

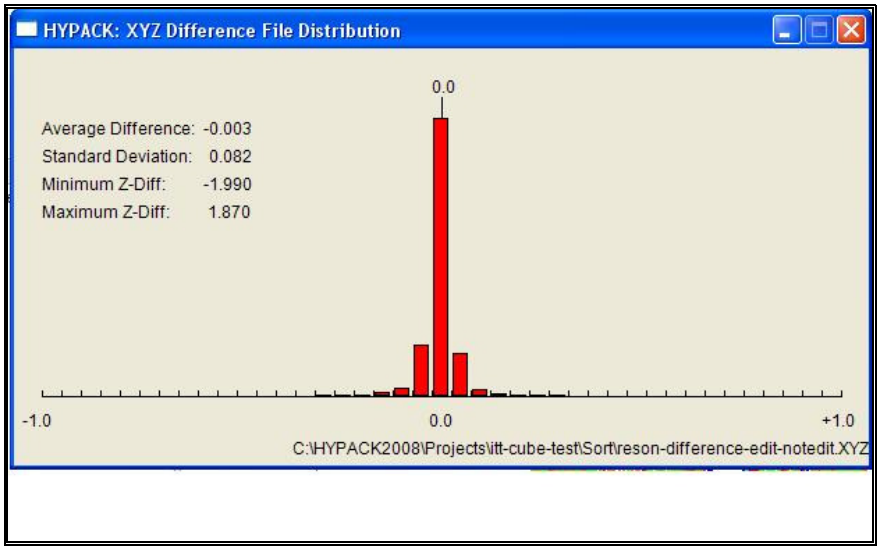


Pic.13 Differences distribution between Max-Edit and Min-Edit data (Reson study).

With the Reson data, I didn't remove outliers in XYZ Difference program. But still, the biggest differences are -1.16 and 0.91m, average is 0mm and the Standard Deviation is only 2.9cm between the Min-Edit and Max-Edit data.

In the case of No-Edit data (picture 14), the differences are bigger. The average difference is -3mm, the minimum difference is almost 2m, the maximum is 1.87m and the Standard Deviation is 8.2cm.

From that second set of the Reson data, it is obvious that application of minimum filters in MBMAX can be very useful before running your data into HYCUBE. You can get quite qualitative data after spending one hour in MBMAX instead of spending some days in MBMAX!

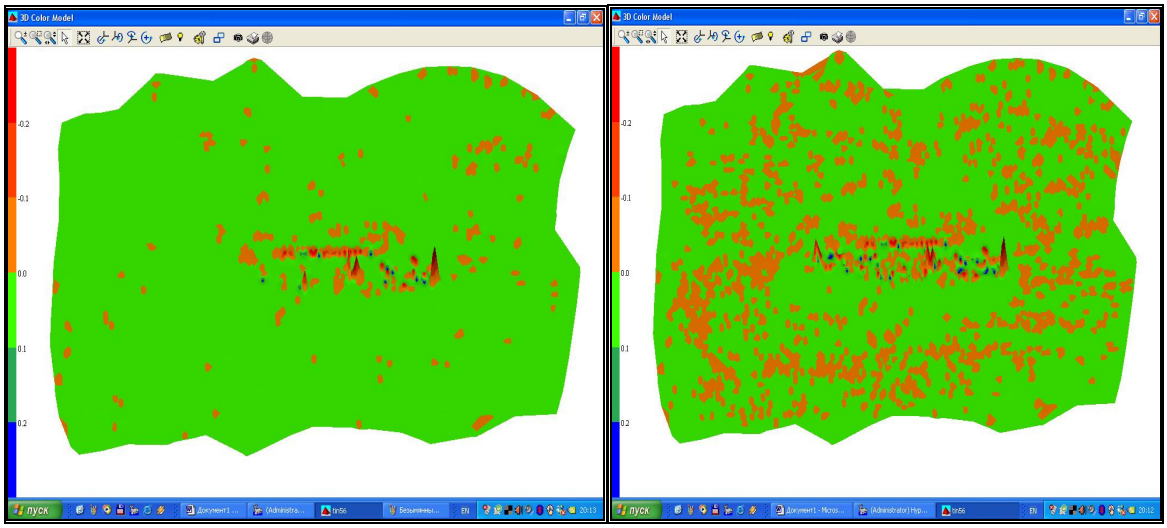


Pic.14 Differences distribution between Max-Edit and No-Edit data (Reson study).

Wreck Inspection Data

In my last study, I took the data from inspection of the M/V Sulina wreck. This dataset was also collected with the Reson SeaBat8101 MBES.

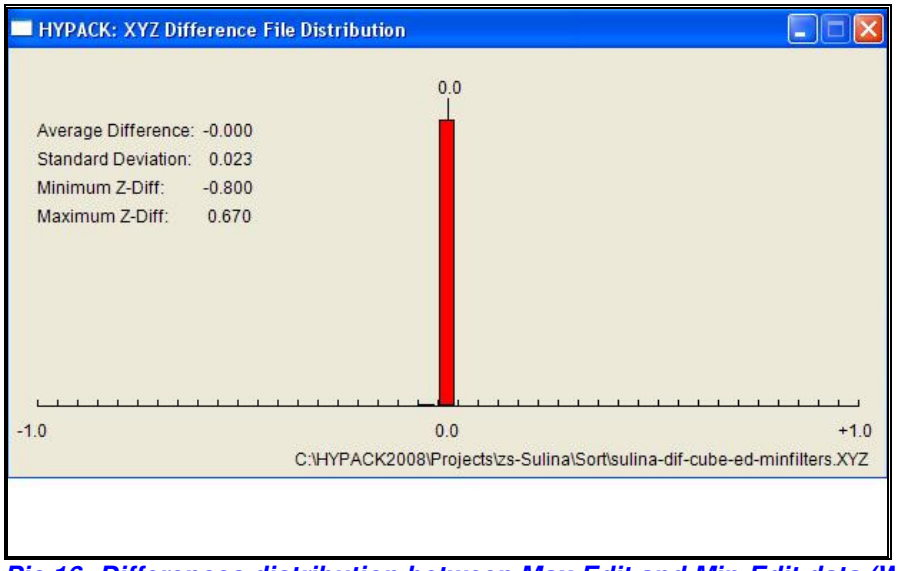
In this study for Min-Edit case, I didn't filter too much. I just used Beam Angle filter (cut to 65°), and the min and max filters and that's all.



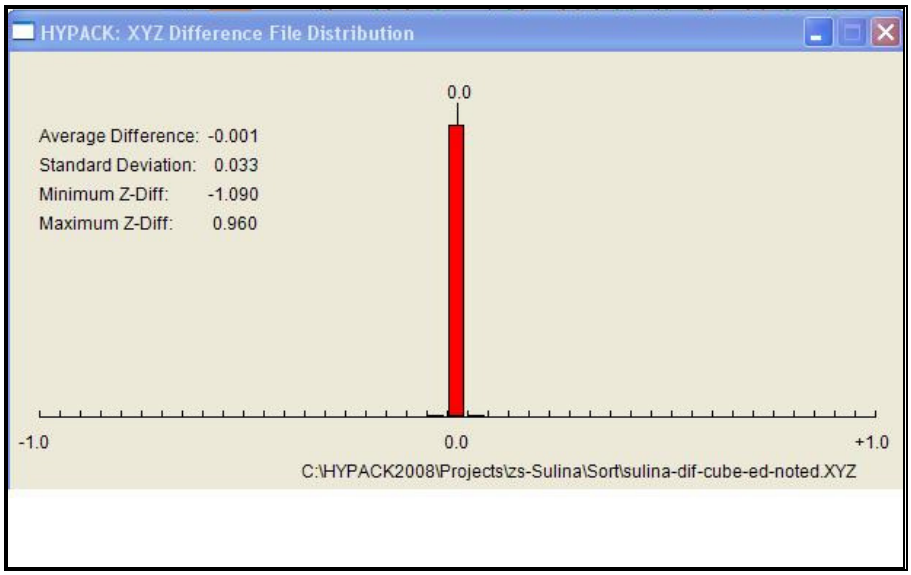
Pic.15 TINs of differences for Min-Edit (left) and No-Edit (right) data when compared with Max-Edit data (Wreck study)

You see that overall differences in the Min-Edit case is much less than those in the 'No-Edit', but still it is not too big for both cases.

But if we'll look at the distribution histograms, it is clear that the differences between either the Min-Edit vs. Max-Edited data and the No-Edit vs. Max-Edit data are not as big as in previous study. The Min-Edit vs Max-Edit differences had an average of 0.000m with a Standard Deviation of 2.3cm. The No-Edit vs. Max-Edit differences had an average of 1mm with a Standard Deviation of 3.3cm. The biggest outliers in both cases are almost the same.



Pic.16 Differences distribution between Max-Edit and Min-Edit data (Wreck study).



Pic.17 Differences distribution between Max-Edit and No-Edit data (Wreck study).

Conclusions

In my opinion it is useful to apply minimum filters in MBMAX before your loading data into HYCUBE. But in general, it is not critical in all cases, as the averages and standard deviations were small (except with the Geoswath data, collected without pre-filters).

This test was very brief and shouldn't be treated as something absolute. We must make a deeper investigation with different MB systems and with different surroundings (for example, over the muddy and sandy bottoms) etc.

But why spend a lot of time editing your MB data if HYCUBE do it much quicker?!