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Interactive comment on "Processing of water level derived from water pressure data at the Time Series Station Spiekeroog" *by* L. Holinde et al.

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Review: GENERAL COMMENTS : Thank you for this comprehensive work. Maintaining a sea level station is a lot of effort and it is important to take time to quality check the data series in order to make it available to as many applications as possible. In your case, it is unfortunate that regular quality controls have not allowed correcting the sensor drift and preserving a vertical reference. Indeed, as you mentioned, it is not usable for climate change studies or extreme level statistics. Local Storm detection is a good idea but without a vertical reference attached to the ground datum it not possible to make comparisons with ground references. However, it is a good work for calculating harmonic constituents that do not include meteorological effects and long term trend. The constituents can be then referred to the lowest astronomical tide (LAT). For the

coming years, it is highly recommended that a more reliable sensor (like radar sensor) is installed and a vertical reference adopted in order to fully benefit from the Spiekeroog station.

Reply: Thank you very much for your helpful comments. A radar sensor has been attached to the station in 2013 as a second measurement system for sea level changes.

Review: As it is said in the other referee comments, I found dangerous to keep interpolated points over 7h in the final series. It is common to interpolate small gap over 1h using Spline interpolation but you can miss a lot of local phenomena in 7h. Indeed, a future user may not be able to distinguish real measurements from interpolated data and this can be misleading in case of a study on a local phenomenon. Your interpolation using a nearby station is still interesting and allows calculating a FFT on a continuous series that can lead to better results than other methods. On this topic, you may want to use academic Tidal analysis tools : Please, refer to http://www.psmsl.org/train_and_info/software/analysis.php. Once you have done the FFT, I am not sure interpolated points should remain in the final dataset. That is why I think it was a good idea you have created the three different datasets L1, L2 and L3.

Reply: One reason for filling the gaps was to create a continuous time series which is easier to analyse by a FFT. Another tidal analysis tool is t_tide, but this method was not used because we wanted to focus on the processing of the data and not the analysis. In addition, our data were compared to model results in other projects.

Review: Concerning the 20 minute delay between Spiekeroog and Neuharlingersiel, you may have to check that both instruments are well synchronized in time, but, if it is the case, it may be explained by shallow water effects that slow down dramatically the tide propagation at the coast like in estuaries. General tide models may sometimes not take into account such local effects and that is why in-situ observations are so much important. Moreover this delay may significantly (from 5 to 30 min) change between Spring and Neap periods, that is why it is not very representative to give only one value.

Reply: The data from Neuahrlingersiel and the TSS have been synchronized before the comparison. We will take a look at the differences for Spring and Neap times and add further data if it is required

Review: 1 Introduction : As it is said in the other referee comments, it would be necessary to give a larger description of the installation (sensor?, datalogger?, transmissions?), the acquisition parameters (what is the vertical reference and is it linked to the ground ? Time reference? Averaging period?) and the maintenance procedures (How the vertical and time reference are controlled, what kind of maintenance is done on the sensor?). In particular, if you have vertical controls done during every maintenance, you may prefer use the trend between two controls, rather than an overall period trend in order to keep closer to the reference.

Reply: Yes, more Meta data will be added.

Review: 2 Methods : 2.1 : - Regarding Figure 2, it is clear that the sensor drift is not constant over the whole period. Is there a correlation between the sensor drift and the brand or serial number of the installed sensors? - Please, could you precise how you calculate your short and long term trends? Do you compute daily mean sea levels? Monthly? What are your criteria to differentiate these two trends?

Reply: The brand of the pressure sensors was the same during the whole time. But three different were in use during the time. The Information concerning the sensors and maintenance will be added to the paper.

Review: 2.3 : - You should precise that Neuharlingersiel sensor falls dry during “Spring” low tide only and not at every low tide. Indeed, that is why it was possible to interpolate at Neap low tide in your example. - What do you mean by similarities between the two sites : I assume you perform a linear regression on High & Low tide in order to determine an offset and a scale factor? Please can you develop this part?

Reply: We will improve the description of calculation the supporting points and empha-

size that data from Neuharlingersiel is not taken when the sensor reaches its minimum value. We have performed cross correlations between the two sites to determine the time lag. In addition, the mean low and high tides were compared for differences between the two measurement stations.

Review: 2.4 : Could you precise what is the maximum gap authorized for spline interpolation. You refer to a "tidal cycle" but for me a tidal cycle is 12h25min. . .

Reply: Using a spine interpolation on gaps smaller than a tidal cycle (12.5 h) still produces results which are comparable to measured results. This means there are no obvious differences at high or low tide. For longer gaps, the interpolation spreads the tidal cycle over whole gap and calculates high or low tide values which are unrealistically high/low.

Review: 2.5 : - As a quality control, you could have compared tidal analysis over every one-year period and check discrepancies between the results (assuming, tidal constituents are constant over a 10 year period). - If you have the tools to make your own predictions, you can also detect the storm signals using the residual observations-predictions.

Reply: Thank you for the tips. This very helpful when we are publishing the next datasets.

Review: 3 Results 3.1 - Figure 4, bottom graph : Can you explain the event around march 2008 (I suppose it is the storm Emma) that is clearly visible in red but not in blue. It may put into question the correlation between the two sites. However, it seems on figure 7 that the storm Emma (n_ 6) reaches approximately the same range at both sites and is detected as a weak storm flood. - You give the results of the correlation but what are the results of the height comparisons? Is there a scale factor between the two sites? Does that mean that no height correction is applied to Neuharlingersiel values when creating the supporting points?

Reply: Shortly before the position you are mentioning is the event of storm Emma. The red lines are some outliers which have been removed as in figure 7. We will also remove them here in the corrected version. Section 3.2 mentions the mean high water level for the TSS and Neuharlingersiel which are the same (1.33 m).

Review: 3.2 - I am not an expert on FFT but FFT is not supposed to work on non-continuous data series. Can you explain how has it worked on the dataset that contains gaps? Usually, for dataset with gaps, I use a kind of root mean square error adjustment.

Reply: In this case the missing data was replaced by zeros.

Review: 4 Discussion 4.1 You will have fewer problems if you use a radar sensor that is above the sea surface. Using the digital output also avoids the natural drifting of the analog components.

Reply: A radar sensor was installed in 2013 as a second measurements method. The data is transferred as a digital signal. The only analog components used is the pressure sensor and a signal booster.

Review: 4.2 - The Figure 3 is essential to validate your threshold. You should clearly precise that for another site this threshold may have to be adjusted with regards to the local tidal range. For example, in France, at Saint-Malo, with a tidal range of 14m at Spring tides, you can reach a gradient of around 6cm/min at mid-tide.

Reply: We will do that.

Review: 4.4 - To validate your interpolation method, you could have made artificial gaps by removing some points of your series and then make error statistics comparing the original observed data and the interpolations.

Reply: Thank for the tip. We use that when we validate the results from further processed years.

Review: 4.5 - It is possible that working on a continuous series can improve significantly

the result of the FFT.

Reply: That was our idea behind interpolating the missing data.

Review: TECHNICAL CORRECTIONS : 2.2 : Figure 3, the unit of the gradient should be .10-1m/min

Reply: We change the information accordingly.

Review: 3.2 : - You can delete the “probably” in the sentence “The highest peak in the original time series is directly at beginning of the graph probably representing the mean of data.” - I would add an “s” at “floods” in the sentence “Table1 shows the water level during the storm floods above the mean high tide and the name of the storms.”

Reply: Thanks

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