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Interactive Comment

Interactive comment on "Does temperature affect the accuracy of vented pressure transducer in fine-scale water level measurement?" *by* Z. Liu and C. W. Higgins

Anonymous Referee #3

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Full disclosure: This reader is not a hydrologist. I am interested in data quality and this is one of the important aspects of this paper. My comments should be taken as being from a naïve reader who would like make the paper more accessible to other readers like myself.

Overall the paper is concisely prepared and makes a good case for error analysis of pressure sensor data in the context of precision water level measurement. However by the end of a detailed reading it seems to this reader that as good as this error analysis is, it could be describing an error source that may be relatively insignificant when taking into account the entire detection/estimation system. One need delve into the relevant literature to be certain but it seems to me that the flow calibration of the weir needs to be related to the pressure sensor errors and then placed in context of what are all the significant measurement errors. Also, and this may be a show-stopper, the variation of water viscosity with temperature would introduce flow rate errors possibly much greater than those created by pressure measurement imperfections. I do not know what is standard practice with respect to the calibration of weir flow vs temperature. I must leave that to the practicing hydrologist.

Here are some 'back of the envelope' estimates.

Over a 20K [10-30C] temperature swing the dimensions of the weir container will change about 0.1% due to thermal expansion of the materials. For a 0.5m water head that introduces 0.5mm pressure error.

Over a 20K [10-30C] temperature swing water density changes about 0.5%. For a 0.5m water head that introduces 2.5mm pressure error – similar in magnitude to the transducer errors. [Note that this error and the previous one tend to cancel each other. One might get lucky and find an ideal flow container material that results in a really good cancellation.]

Over a 20K [10-30C] temperature swing water viscosity changes about 35%. This must cause massive changes in flow rate.

I did delve somewhat into the literature looking for 'state of the art', so to speak, and into the reference list. I did find two papers by Constantz from 1994 and 1998:

"Influence of diurnal variations in stream temperature on streamflow loss and groundwater recharge", Jim Constantz, Carole L. Thomas, Gary Zellweger. WATER RESOURCES RESEARCH, VOL.30, NO.12, PAGES3253-3264 DECEMBER 1994

"Interaction between stream temperature, streamflow, and groundwater exchanges in alpine streams", Jim Constantz, WATER RESOURCES RESEARCH, VOL. 34, NO. 7,

PAGES 1609-1615, JULY 1998

Both these paper address the issue of viscosity change with temperature and what then happens to stream channel flow rates. These may shed light on the issues most of concern to me here.

With respect to the paper's references I took the time to examine in particular both Grant and Dawson, and Sweet et al. The former is a basic handbook regarding weirs, flumes and the like. The 1995 version I could access makes no mention anywhere of either temperature or viscosity variation with temperature. Sweet et al is a paper which discusses measurement of essentially standing water in boreholes where viscosity variation with temperature is also not discussed, but in that environment it is irrelevant with respect to measurement error. I feel the way they the two have been cited by this paper is at the very least confusing. In the context of viscosity induced error they add nothing. Why they have been cited needs clarification.

With some thought additional error sources might be identified. In the context of the present paper all these errors could be significant. Neither this paper nor the cited references take these error types into their discussions. For the GI Journal which must be considered a general audience such a discussion is needed in this paper. Thus I recommend the authors revise and resubmit, placing the present results in the wider context of temperature induced errors in the entire measurement system.

What follows is a large list of minor English errors, mixed with comments on the paper's content.

p2, l4 “widely” should be “wide”

p2, l5 “reported for” should be “reported regarding”

p2, l6 “effect” should be “effects”

p2, l7 “were discussed” should be “were considered”; “The pressure transducer was” should be “The pressure transducers were”

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p2, l13 “effect” should be “effects”

p2, l26 “as gauge” should be “as a gauge”

p3, l2 “absolute” should be “an absolute”

p3, l8 “there are” should be “there is”

p3, l25 Do the authors mean “further thoughts which led to the mathematical...”?

p5, l2 “The CTD sensors were installed...”

p5, l7 “Alsea site” should be “the Alsea site”

p5, l9 “can protect” should be “would protect”

p5, l10 “The water level is at the bottom of the weir” I was a bit confused here. To help readers such as I it would be helpful to identify the weir as being precisely the v-notch which is cut into the side of the flow container, either here or a paragraph earlier in the paper. Also in Fig 1 I think I do not see any collection pipes. Are they buried?

p5. l13 “bucket” Is this the same as “container”? If so it could be restated as “The water level inside the container will rise and water will flow out through the weir.”

It may be useful to expand the device description here a bit further. Without access to Stewart et al (2014) the reader is left to rely entirely on what is presented here.

p5, l13 “is one minute” should be “was one minute”

p5, l23 “to a minimum extent” should be deleted

p6, l5 “within each pressure transducer” As stated this means that for a single transducer, perhaps from time to time, or from temperature to temperature there exists a varying baseline shift sensitivity. There is some evidence for this which shows up as curvature in the data plots of Fig 3. This would imply the linear regression in Fig 5b would not be entirely appropriate. On the other hand if what is meant is that comparing any two transducers one finds different baseline shifts then perhaps a better wording

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for this bit of sentence is “...the effect differs between pressure transducers”.

p7, l5 “Figure 4 shows a schematic of the derivation” I believe this model makes the assumption that the two ends of the vent tube are at a common elevation. In principle the thermal effect of expansion should include that caused by the gravitational potential caused by differential air densities inside and outside the vent tube. I did the calculation for myself and satisfied myself that it is a small effect, but in the interest of thoroughness the authors may wish to address this detail.

There is also a similarly small effect which will reduce the cable’s temperature sensitivity due to thermal expansion of the cable, which must occur simultaneously with that of the air inside the vent tube. The volumetric thermal coefficient of air will be the order of 3000 ppm/deg, while that of the cable materials will likely be in the range 150-300. Thus the proposed cable thermal effect will be reduced from that predicted by about 5%, worst case 10%. This is not significant. It does however bring to mind an expression: “Everything is a thermometer, but some are better than others”.

p7, l10 “ML/T2” It took me a short while to see that this and other similar expressions are dimensional notations. A note to that effect would be helpful. The journal may have some preference regarding best or preferred practice. For certain negative exponents are preferred over “/” characters.

p9, l1 “radical” should be “radial”

p9, l3 “Insert” should be “Inserting”. Also p9, l13

p9, l11, “written into” should be “written as”

p9, l16 “Solve” should be “solving”

p9, l 20 “proportional to the thermal gradient” might better be “proportional to the thermal time derivative” as “gradient” is often assumed to be spacial rather than temporal. Also Eq. 14 is the key result of the modeling work in this paper. One could usefully add to this sentence “, the viscosity of air and inversely to the cross section area of the vent

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tube”

Eq 14 Starting from (13) I don’t get to (14). Should not the exponent on alpha be one? Should not there be an “L” in the numerator? This needs to be rechecked carefully. Just on the basis of “look and feel” it makes sense that higher viscosity will lead to higher pressure errors. Also larger cross sections lead to lower errors. Longer tubes would also imply a need for larger pressures or longer time lags.

One can do a thought experiment. An instantaneous change in air temperature would lead to an equally instantaneous change in pressure, mediated by the coefficient alpha. That pressure jump would then decay to ambient with something like a time constant. An equally instantaneous change in ambient air pressure would have the identical effect, same time constant. In both cases a longer tube will slow things down.

Using alpha to adjust temperature to pressure [a corrected] Eq (14) provides a system time constant. At this point it would be useful to obtain actual numbers for the various parameters and to work out an actual value for the vent tube system time constant. Not for the present study, but perhaps it would be possible to actually measure the vent tube time constant, say by placing an inflated balloon over the vent tube open end, suddenly deflating the balloon, then monitoring the sensor error transient?

p9, l21 “Fig 5a” Which sensor as shown in Fig 3 supplied the data for Fig 5a and for Fig 5b? It’s probably Transducer 2 with its 40mm swing – just want to be sure.

p10, l3 “stain gauge” should be “strain gauge”

p10, l5 General comment on Fig 5.

Taking into account the paper as a whole, particularly the recommendations at the end, particularly recommendation 5, it occurs to me that the data in Fig 5, both 5a and 5b, could be used immediately to demonstrate what is achievable in terms of correcting for thermal errors. Using both the regression results a new, corrected plot should be possible, taking into account both error types, and plotting water level vs time. Also

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one significant thing that is missing from Fig 5a is a definition as to what is meant by "Temperature Gradient". Are these values all first differences, or are the deltaT's taken over longer intervals than the minimum possible?

p11, l10 "experience baseline shift" could be "experience a significant baseline shift"

p11, l11 "not sharp under indoor condition" could be "not sharp, i.e., under indoor conditions"

p11, l20 "noises" should be "noise",

p11, l13 "noises in the signal were" should be "noise in the signal was"

p11, l25 "noises were" should be "noise was"

p11, l29 "with" delete

p12, l2 "to an electrical signal" should be "as an electrical signal"

p12, l3 "Poor or nonexistent ... as the water density is normally effected by the temperature" Is this relevant? Yes, poor strain gauge temperature compensation causes measurement errors. But are you trying to measure water mass quantities or water volume quantities or what? Thermal variation of water viscosity will cause flow rate errors at the weir, will it not? Doesn't the large variation in its dynamic viscosity over the same temperature range cause havoc with trying to calculate actual flow rates? Are these compensated somehow? Same for the dimension stability properties of the flow container itself though such errors aught to be relatively small. If the water temperature is varying what else are its error paths? How do these relate to the present discussion?

p12, l18 "Under the field conditions" could be "Under typical field conditions"

p12, l20 "weathers" should be "weather"

p12, l24 "A long-term field monitoring data was" should be "Our long-term field monitoring data are" p12, l25 “used in the field test is pressure transducer 3 as in the above laboratory test”

p13, l2 and elsewhere “flow bucket” or “flow container” Consistency is needed.

p13, l8 “recored” should be “recorded”

p14, l3 “Figure 8 presented a zoomed-in” should be “Figure 8 presents an enlarged”

p14, l4 “decrease at 1mm step” should be “decreased in 1mm steps”

p14, l5 “corresponded” could be “correlated”

p14, l6 “noises” should be “noise”; “ranges” should be “range”

p14, l8 “when” should be “When”

p14, l14 “looked” should be “looks”

p14, l27 “as the its” should be “as to its”

p15, l1 “showed” should be “shows”

p15, l10 “showed” could better be “illustrate”

p15, l16 “and contact” should be “and in contact”

p15, l17 “in dry” should be “in a dry”

p15, l18 “like” should be “likely”; “could” should be “would”

p15, l22 “using vented” should be “using a vented”

p15, l23 “like” should be “such as”

p16, l3 “noises” should be “noise”

p16, l4 “effect” should be “effects”; “experiments” should be “experiment’s”

p16, l10 “produces more noises” should be “produced more noise”

p16, l12 “was” should be “were”

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p16, l14 “noises” should be “noise”

p16, l15 “various thermal compensation algorithms” could better be “differing individual compensation errors”

p16, l18 “dropped” should be “drop”

p16, l23 “other” should be “if all other”

p17, l2 “predictable” should be “are predictable”

p17, l8 “monitoring. Frequently” should be “monitoring, frequently”

p17, l9 “if” delete

Interactive comment on Geosci. Instrum. Method. Data Syst. Discuss., 4, 533, 2014.