Reply to review #1

Brief Communication: The Danish Replicate Drilling System – Results from the First Field Test

Author(s): Westhoff and others

General comments

I find the paper is interesting and relevant, and worthy of publication. The paper is well illustrated, but could still be improved fairly easily.

Thank you very much for the positive statement.

First, I suggest inserting very early on a few lines (no more) on why a core deviation and/or a duplicate core might be needed. Incidentally, I would refer to the second core as a 'duplicate' and not a 'replicate'.

We will include a few lines in the beginning introducing the necessity a bit more. We will also change the terminology to duplicate.

Second, I would consider the method-related terminology and stick to it throughout; as written, I have no doubt that the terms are correct, but I was still a little confused by the process (involving milling, cutting, grooving and broaching). I think this comes from a need for a simple (or at least as simple as possible given it is quite mechanically technical) explanation of the process from the outset, followed by consistent use. If I follow the technique correctly, I might suggest a summary something like: "The method is based on adapting the corer to incorporate three key functions. First, a retractable broaching tool cuts a vertical groove, ~30 mm wide and up to * mm deep, along the borehole wall. Second, a spring sleeve, which bows into and slides along that groove, retains the corer in a consistent and known orientation. This spring sleeve also pushes the base of the corer laterally away from the keyway, raising the cutting head's contact force on the opposite side of the borehole wall. Third, a milling head (with the ability to cut sideways as well as downwards) is used to mill into the opposite side of the borehole wall under this enhanced force." (Incidentally, one could also refer to the groove as a 'keyway', but I'm not sure the technical accuracy outweighs the rarity of the term; 'groove' would be good enough for me).

Thank you very much for the suggestions. We will implement the explanation given by you to increase clarity. We will add this to a short section where we introduce the terminology.

Third, and again if I understand correctly, the reported application demonstrates the use of the technique to create a shelf from which it should be straightforward to core a new hole. However, this duplicate coring is not guaranteed, and the manuscript does not actually report that new duplicated coring. This needs to be acknowledged.

We agree that a duplicate core is not drilled in our test. The shelf nevertheless is a very high guarantee to produce this core, as has been demonstrated, e.g. in the NEEM core. We will acknowledge this and clarify.

Fourth, several pointers for future improvements, refinements and applications are given at various places in the manuscript – most notably in 2.4.3. However, this is not the only place potential improvements are raised or implied. I would retitle 2.4.3 as 'Trial application' and insert a new subsection on 'Future improvements' (or similar) into the Discussion or the Conclusions.

We will include a section about further improvements to the end of the manuscript as suggested.

Specific comments Line/Location	Comment/Suggestion
11	'…in the EastGRIP…' will be corrected.
11-	Here, I think the explanation would benefit from being presented more clearly. It also doesn't have to be the downhill side – in fact, I think this is a bit of a red herring and I might not mention it here at all. Perhaps mention that the process can be assisted by using gravity on a non-vertical section of borehole. Thank you for the suggestion. We will adjust it accordingly.
20	I'd delete '…in the borehole…' to end of sentence. Will be done.
24	'The replicate system…' (and I'd refer to it consistently and solely as a 'duplicate' system). Given the two possible uses, I might even refer to it as a 'deviating/duplication system' (sounds awful though). According to EPA.gov "**Duplicate**: an adjective describing the taking of a second sample or performance of a second measurement or determination. Often incorrectly used as a noun and substituted for "duplicate sample." Replicate is to be used if there are more than two items. See **Replicate**. **Replicate**: an adjective or verb referring to the taking of more than one sample or to the performance of more than one analysis. Incorrectly used as a noun in place of replicate analysis. Replicate is to be used when referring to more than two items. See **Duplicate**." For the first deviation from the bore hole, we thus drill a duplicate core. Yet we would like to leave the option of also making a 3rd hole further up to get another sample. This would make it a replicate tool. We would therefore prefer the term Replicate.
26	'…2500 m…' (insert space) Will be done.
38-41	'We performed another test at the NEEM site, in a dry 400 m deep borehole of local inclination ~4°. Here, the inclination was sufficient to mill into the side of the borehole under gravity alone, cutting a quasi-horizontal ledge into the borehole wall.' (I'd not dwell on this being unpublished, since you are doing so here). Thanks for the suggestion, we will adapt this.
56 & 105-110	The manuscript presents little information on this orientation package and the data are also not presented. I think this verification claim does need to be demonstrated in the main text. Alternatively, if the data somehow fall short, at least alternatively refer to 'future application of…

	But it'll still ideally need a reference, and it would be nice to see the corroborating inclination data. See comment to figure 3.
60-61	I would put the source attribution in the Figure caption and just refer to 'Supplement 8' at the appropriate point in the text. Will be changed
Fig 2 (& 71)	I'm not convinced this needs to be inclined. Since the technique needs to be deployable anywhere along a borehole (by the manuscript's own requirement section) then a preexisting inclination cannot be a requisite. Also, for me it detracts from the core technique of the spring pushing from the keyway. It also confuses since the application in the manuscript is the other way around… I'd just mention that a pre-existing inclination helps mill into the downhill side (with the uphill side broached) – as long as the orientation is suitable for the need. Perhaps all of 71 – 75 can be reworded to account for this. There is actually a need for some inclination. Yes, we can mill in a plumb hole because we have the spring. But the drill will not fall onto that ledge if there is no inclination, it will stay in the original bore hole. Therefore, it's true that we do not meet the requirement of deploying anywhere in the borehole with this requirement. However in our experience, there has never been a perfectly plumb hole, so we accepted this short-coming for the technique. I would label spring sleeve and ledge on panel C; also the groove/keyway on B. Will be added
76	'The system needs to comply with certain operational requirements:' Thanks for the suggestion
83	'…diameter.'
84	The system must operate at…
2.2 Subtitle	'System deployment and testing' (?) Thanks for the suggestion, we will adjust it.
Fig 3	Are there any orientation data to refine panels H-J? To verify the rotation of the drill, we used the live-rotation in a few-degree increments. This does not change the orientation of the drill's azimuth and inclination and is not recorded in our software.
90	'..cable tension excursions.' 'g-j) show lateral milling of a ledge in the borehole wall, indicated by…' Will be adjusted
105 – 110	Are these orientation data not available to be shown as a log alongside e.g. Fig 3H-J? See also comment on line 56 above.
120	'..groove in the borehole wall.' Will be adjusted
120 - 123	Again, this is a slightly different way of describing the technique and process. I would select one description and either not repeat or, if repetition is needed, stick to almost exactly the same wording to avoid any possible confusion. I would also remove the role of off-vertical inclination

from the primary description – in the first instance assuming a vertical borehole and only once described noting that an off vertical inclination can help through gravity.

Thanks for the suggestion, we will adjust it.

133-134 We then raised the drill by 20 m and lowered it again. By rotating another 90° (resulting in a total rotation of 180°)… Will be added

134-135 Can the 5 mm deep keyway be explained? Is it that a certain depth of material is removed during each pass?

We will add the following: A 5-mm groove I sufficient and necessary to guide the spring of the milling tool for the next step.

148 Move to new future refinements section? Thanks for the suggestion, we move this statement.

151 Interesting. Just from personal reference, I imaged what I think must have been a similar helix (I imagine from the normal teeth) at ~170 m depth in the NEEM borehole wall. See Figure 3d here: http://dx.doi.org/10.3189/2013aog64a201. Happy to share the original if you want it – but I don't think this paper needs it. Thanks for hinting us to the paper, we will reference it for visualization

157 'The spring sleeve is designed to push the milling head into the opposite side of the borehole wall.' (This is simpler and avoids reference to a 'radial' force – which I am not confident of).

Thanks for the suggestion, we will adapt to your phrasing.

161 'AT' needs defining

170 Sampling frequency improvement could be included as a future refinement. That is a good point, thank you.

182 'During upwards drilling, the blade faces upwards and the chips…' Thanks for the suggestion

188 '…(not plotted). We started…'

190 '…slow descent and…'

196-197 I leave this up to the authors, but I think I would remove the effects of this power-outage from the data (and note that it was done); it is clearly an artefact. Thanks for the suggestion, we will remove the artefact datapoints and mention it.

200 'After milling into the borehole wall…'

205 '…the ledge, as evidenced by no drop in…'

210 '…test, possibly by degrading the integrity of the ledge by repeated contact.'

217-220 I'm not sure this distinction needs spelling out again – the manuscript already stated that the test was the 'wrong way around'. We will remove this section.

224 A future development to add to the list? Delete '…, which we could not do with our test'

225 Also need to consider chip removal as a future development since one of the manuscripts stated requirements is to be able to deviate-duplicate at any depth (below casing I imagine).
We will include the chips removal to future development. Below the casing is stated in line 85.

235 '... will improve further the effectiveness of this technique by supplementing the force imparted by the spring sleeve with that resulting from gravity.'

Thanks for the suggestion and all the detailed comments to improve the quality of the manuscript.