

Interactive comment on “Transboundary geophysical mapping of geological elements and salinity distribution critical for the assessment of future sea water intrusion in response to sea level rise” by F. Jørgensen et al.

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General comments:

This is a very good paper that reads like a mystery novel: authors provide good review of the background material, present the evidence and logically and in great detail develop the story of what could have happened. I am particularly impressed with the insight and depth of geological/hydrological interpretation of geophysical data. I liked

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the structure of the paper, where in a systematic way different kinds of geologic structures were examined in depth. For example, a very nice, logical description of faults sets a tone for the rest of the geological interpretation. Similarly, a likely age of the valley was deduced from analyzing the sequence of the deposit, using the information outside of the immediate study area. Correlation of the induction logs with lithology and inverted resistivity provided groundwater quality estimates. The reader is left with an understanding of processes that shaped the region and their impact on the groundwater flow.

Technical comments: Here are my suggestions, mostly editorial, intended to clarify few sentences.

Abstract Line 11: “deep and shallow buried tunnel valleys” > “buried tunnel valleys (deep and shallow): Line 13: “elements” > “structures” ? Line 19: “The salinity distribution” > “The mapped salinity distribution” Line 20: “geological elements” > “geologic structures” Line 22: “system and chemical status” > “and groundwater chemistry”

Introduction Line 1: IPCC not in references Line 1: “and this will result” > “resulting” Line 2: “increasing problem of saltwater intrusion, globally” > “global problem of saltwater intrusion” Line 15: “the wedge” > “the wedge of saltwater” Line 21: “remain” > “remains” Line 23: “These studies” > “These theoretical studies” Line 25: “newer” > “never”

Intro p. 5 Line 5: Yechiely not in ref Line 6: “or reversely” > “or, reversely,” Line 26: “advantageous within” > “advantageous to” ??? Line 27: Teatini not in references Line 27: “are important” > “provides important” ?

Intro P. 5 Line 1: “as well as” > “and” Line 15: Tetini – not in references, and it was Tatini before Line 20: “making detailed structures hard to define precisely with TEM data only: > “making it difficult to obtain detailed structures using only TEM data” Line 21: “even at greater depths” > “at greater depths than TEM” Line 24: “determined” > “obtained” (because “determined” is already used in this sentence)

Hydrology and hydrogeology Line 24: “is characterized as” > “is” Line 25: “farm lands”>” farmlands”

P.8 Line 2: “and make” > “and to make” Line 4: “are pumped”>”is pumped” Line 14: “shallow lenses of freshwater” > “shallow freshwater lenses” Line 16: “compared to the situation in polder”>”compared to polder”

Geology Line 24: “The geological setting is composed” > “Geology consists” Line 24: insert “(Fig.3)” after “sedimentary sequences” Line 25: “of around 300 m in the area” > “of about 300 m in the study area” Line 26: “followed by” > “overlain by” (“overlain” makes it clear it is located above)

P.9 Line 1: “followed by the fine-grained Gram and Hodde Formations at the top” not quite clear: on top of Miocene? > “overlain by the fine-grained Gram and Hodde Formations” ?? Line 3: “(10-40 m) but in places where tunnel valleys incise the Miocene and Palaeogene, they can be considerably thicker” . “(10-40 m). These glacial sediments, in places where tunnel valleys incise Miocene and Palaeogene formations, can be considerably thicker as shown in Fig. 3” Line 8: where is Fano Bugt? Line 10: “km-wide”>”kilometer-wide”?

Methods SkyTEM P.10 Line 5 “square meters” > “square meters area” Line 5: “small receiver loop of less than 1m²” > “small receiver with multi-turn loops with effective area of 31 m²” ? Line 9: “and get” > “and to get” Line 12: “measures with two moments” > “operates with two transmitter moments” Line 13: “and one called”: > “and the other called” Line 14: “for each single sounding” > “at each single sounding location” Line 16: “To ensure corrections due to the movements of the frame. . . 2009)” > The height of the frame is measured by laser. To ensure corrections for the movements of the frame, pitch/roll are continuously measured by inclinometers (Auken et. al., 2009).

Seismics>Seismic Line 23: “inside the earth” > “inside earth” Line 26: delete “nowdays”

P.11 Line 1: “S-waves. Both differ” > “S-waves that differ” Line 5: “The depth penetra-

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tion is realizable” > “This penetration depth is realizable”

Borehole geophysics Line 11: “typically measures” > “typically measure” Line 12: “reflects” > “reflect” Line 21: “probe also record” > “probe also records”

Surveys Performed Keep consistent use of past tense. Line 4: “(Fig. 5)” > “(red lines in Fig. 5)” Line 6: “2009” > “2009 (blue and green lines in Fig. 5)” What is the significance of different colors? The lines are thick, they cover the underlying map, maybe thinner lines with the names of the towns being more pronounced? Line 12: “tens of meters” > “tens of meters from the surface” Line 13: “The resolution. . . . towards the depth” > “The resolution decreases with depth because of the diffusion of the electromagnetic signal with depth.” Line 19: “removed from the data set”>”removed from the data set (compare figures 5 and 6)” Line 21: “trapezoid” > “trapezoidal” ? Line 23: “as the time after the turn-off of the source a” > “with time after the turn-off of the source”

P. 13 Line 8: “too smoothened” > “overly smooth” Line 15: “of these” > “of layers”

Seismics>Seismic Keep consistent past tense Line 14: “On. . .Hannover) > “On the German side of the border, Leibniz Institute for Applied Geophysics (LIAG) from Hannover” Or P-wave seismic reflection survey was conducted in May 2009 on the German side of the border by Leibniz Institute for Applied Geophysics (LIAG), Hannover. Line 17: “Geometry of 5 m” > “With 5 m” Line 18: “spacing emerge”>”spacing, “ Line 19: “distance.”>”distance was obtained.” Line 20: “qualified” > “proved itself” ??? Line 21: “rage”>”ranged”, “fold is”>”fold was”, “is at least”>”was at least” Line 26: “profile” > “profiles”

P. 14 Line 2: “cover” > “covered” Line 5: delete “mutually” Line 7: “with a distance” > “with a 6.25 m distance” Line 8: delete “was 6.25 m” Line 9: “was conducted by use of” > “used” Line 15: “car generated” > “car-generated” Line 30: “depth section” > “depth sections”

Borehole geophysics Line 4: “investigated by logging probes” > “logged” Line 4: “area”

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> “area:” Lines 7-8: “were investigated by the use of a combination of different geophysical logging probes including” > “used a combination of” Line 9: “(FTC)” >“(FTC) probes. Line 10: “were logged” > “was logged” Line 17: “ and e.g.”>“and” Line 20: “(or both) e.g. a decrease in the IN log”>(or both).>(or both). For example a decrease in the IN log resistivity”

Results Data interpretation Line 3: “inversion the” > “inversion, ” Line 5; “structures and elements of the subsurface borehole data is a vital constituent.”>“structures, use of borehole data is of crucial importance” Line 7: “investigation” >“investigative” Line 12: “to follow the spatial”>“to follow spatial” Line 12: “The seismic data contribute with detailed”>“Seismic data contribute detailed” Line 20: “intervals of 5 m” > “5 m depth intervals” Line 23: “cell size of 100 m”>“horizontal cell size of 100 m”

P.17 Line 7: add “In what follows, a series. . .” Line 8: “will in the following be outlined”>“will be outlined”

Faults Line 20: “is very electrically conductive” > “is electrically very conductive” Line 21: “low-resistive”> “low-resistivity” Line 23: “low-resistive”>“low-resistivity”

Palaeogene and Miocene Line 6: “show that the”>“shows that the” Line 15: “Miocene sequence is”>“Miocene deposits are” because there are 2 layers ? maybe Line 19: “in both the vertical sections” > “in both vertical sections” Line 27: “high-resistive”>“high-resistivity”

Tunnel valleys – niece logic about the age and correlation of lithology and resistivity with water quality Line 14; “show thick”>“shows thick” Line 15: “low resistive:>”low resistivity” Line 17: “(lithology)”>“(see lithology)” Line 22: “show a much thicker”>“shows a much thicker” Line 26 “Since . . .at this level”>“Since at this depth lithologic logs describe the sediments as sandy, low resistivity suggests, that the formation must be affected by saline pore-water here.”

Glaciotectonics Line 22: (Fig. 9)>(labeled “Glaciotectonic complex” in Fig. 9) Line

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22,23: Delete “These areas are situated . . . survey area” because they are marked already in Fig. 9. Line 25: “low-resistive”>”low-resistivity” Line 26: “both collected in the areas with a . . . resistivity image indicate”>”collected in these areas, indicate” Line 28: “b.s.l.”>”b.s.l. (marked by black line in Fig 7).

Formation resistivity, . . . Niece analysis P. 21 Line 10: I do not see what structures can be traced Line 18: “But it seems likely that valley incision occurred before and after the deformation phase’

P. 22 Line 5: “5-7 Om)”>”5-7 Om, at profile coordinate 26000-32000) Line 10: “Then a low-resistive layer follow”>”A low-resistivity layer is above it” Line 15: Where is A49-3 Line 19: specify what CLIWAT project is Line 28: “reach that low”>”reach such low”

Hydrogeological evaluation P.23 Line 17: “it is, however, likely”>”it is likely,” P. 24 Line 2: “12000 m indicates”>”12000 m indicate” Line 4: “show spot wise”>”show pockets of”

p. 26 Line 5: “generally slightly lower” – not on deep slices 92.5 and 122.5 where the valleys are more resistive Line 16: “groundwater table is here”>”groundwater table here is” Line 27: “interrupted by several structural anomalies including. . . glaciotectonics”>”interrupted by faults, buried valleys and glaciotectonics” Line 28: “and cover”>”and would cover”

p.27

p.28 Line 3: “Above, a qualitative”>”A qualitative” Line 4 “has been formulated.”>”has been formulated above.”

P.28 Line 10: “very critical”>”critical” Line 11: “answers on”>”answers to” Line 26: “transport modeling further . . .”>transport modeling further, additional data collection would be, most likely, required.

P. 29 Line 2: Gannon not in ref. Line 13: “vital importance for the assessment of the impacts of climate change and sea level rise”>”vital importance for the numerical modeling of the impacts of climate change and sea level rise.”

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References Line 19: “highresolution”>”high resolution” Move Spechler after Sorensen
Figures

Fig. 1 Can’t read legend on the right panel – use higher resolution Add symbols to the legend: Roads (thin black line) German-Denmark border (thicker gray line)

Fig. 2 Add German-Denmark border to the legend, change the black line to gray to be consistent with Fig. 1

Fig 3 Add a symbol for Cretaceous rocks in labels?

Fig 4 Fix label on TDEM decay curve

Fig 5 Change the title to: Survey areas flown by SkyTEM. Maybe plot thinner curves and label the towns in a clear way?..’

Fig 6. Mark in text that profiles without names were collected but not used because of poor data quality.

Fig. 7 Black labels could be more visible, white labels are hard to read. Delete the small labels in 167.1538 – they are too small to read. Maybe put a larger version on the right of section like in Profile D2? Headings on borehole log on Profile D2 are also too small Fig. 10 has vertical scale on the bottom left, but is missing here - probably delete the scale from Fig. 10, it’s described in the caption.

In the description Use “Profile D4:” instead of “D4:” and “Profile D2:” instead of “D2:” Replace “by bentonite plugs in this well” > “by bentonite plugs (shown on right of induction log) in this well” Add (maybe): The red dotted line shows seismic-derived depth of incised tunnel valley, blue line shows high amplitude reflection related to the top of Palaeogene, green line???, black lines shows the decollements. Or add another legend to describe the lines on the section.

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Fig 8.

Fig. 9

Fig. 10 Put larger labels on color scale below Maybe mark the projection of the south end of Profile 1 on Profile 2 by an inverted triangle Specify in text “clearly seen on Profile 1 where” > “clearly seen of Profile 1 (coordinate 10000) where”

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