

***Interactive comment on* “Groundwater mean residence time of a sub-tropical barrier sand island” by Harald Hofmann et al.**

Harald Hofmann et al.

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General comments:

Reviewer 2: The authors describe the mean residence times of groundwater in a fresh-water lens on a barrier island in Australia. The paper is generally well written, easy to follow and the methods and their application is straightforward. In general, it is a contribution worthwhile publishing. There are, however, a few points that need to be addressed: The authors tend to focus on rather recent literature to introduce concepts (e.g. lines 38-39, 40-41 but also elsewhere). This undervalues the contributions of the people who developed these concepts in the first place. Priority should be given to the older literature. What is surprisingly almost completely missing is a compari-

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son of the obtained data to other barrier islands, of which there are many worldwide. Several studies have studied the MRT (or age patterns) on barrier islands/dune areas in the Netherlands (Stuyfzand 1993) and on the German barrier islands Borkum, Spiekeroog, Langeoog and Baltrum (search for authors Holt, Seibert, Greskowiak, Massmann, Wiederhold, Post, Houben, Stoeckl etc.).

Response: We thank the reviewer 2 for the positive feedback and welcome suggestions. Our intent was not to give a full review on the salt water/freshwater interface but only to point out that there is a vast amount of literature. We will add extra citations by Holt et al., Seibert et al., Holding and Allen, and Houben et al. on the topic, which have sections on residence times on barrier islands. Many of the other publications mentioned by reviewer 2 is work on the salt water / freshwater interface and biological as well as bio-geochemical processes.

Reviewer 2: A recommendation would be to try to use the analytical model by Fetter (1972, the one with the impermeable basement) to try to recreate the lens shape depicted in Figure 9 with the parameters the authors propose. The age patterns could also be checked against the analytical models by Vacher (1988) and Chesnaux & Allen (2013). Screen lengths of the observation wells are not given but may be an important factor. Considering the low tritium concentrations found, results can be easily affected by mixing, if samples are taken from long-screened wells. Please add info!

Response: These models and others (such as those by Post) have uniform geometries and hydraulic properties. As noted in Fetter 1972, modelling of the freshwater lens in a real island requires that the detailed geometry of the island be taken into account and recharge rates to be well known. Even with these parameters, the assumptions of uniform hydraulic conductivity and steady state conditions will cause some differences with the field examples. This paper is not focused on modelling and constructing such an analytical model is a contribution in itself (as is evident from the many papers that have done this). As noted below, these bores are groundwater observation bores not abstraction bores and have screens of 1.5 m at the bottom above

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a 1.5 m sump. Given these small screens, mixing due to the bore sampling multiple groundwater sources is probably not major.

Specific comments

Reviewer 2: Line 1-2: groundwater use and over-abstraction are related

Response: We will change this to over-abstraction only in the revised version

Reviewer 2: L25: do not agree, the barrier islands along the North Sea shore have no perched aquifers, this might be true for Australia but not necessarily for all barrier islands

Response: We thank the reviewer for this comment and will specify that perched aquifer systems are often observed in subtropical coastal sand islands.

Reviewer 2: L46: I would disagree, there was steady stream of publications on the German barrier islands in the last few years, especially on Borkum, Spiekeroog, Langeoog and Baltrum. Hardly any of the publications are cited in this manuscript (except for Röper et al.), therefore, the statement on the poor understanding of such systems is not valid. Several of these studies explicitly address the topic of residence times (and also of groundwater climate archive).

Response: We have looked at the suggested publications and will add the references to provide more global context. Some of those studies have residence time estimations, however, all of them are in a completely different climatic and geological setting. We will be clearer in the revised version that this is one of the first studies on subtropical barrier sand islands.

Reviewer 2: L130: what was the screen length?

Response: The screen lengths were 1.5 m. These bores are groundwater observation bores not abstraction bores and screen sections are at the bottom above a 1.5m sump. We will add this information to a revised version of the manuscript.

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Reviewer 2: L162ff: I wonder why tritium-helium was not considered, as it frees you from many of the model assumptions of lumped parameter models such as the PFM et al.?

Response: Tritium/He was mainly developed to allow the continued use of tritium following the diminishing of the high tritium activities arising from the atmospheric nuclear tests (the tritium bomb-pulse). The development of low-level tritium analysis also allows achieves this. This is important in the southern hemisphere as the bomb pulse was far lower than the northern hemisphere and has long since decayed; hence most water has tritium activities that are significantly lower than rainfall (<3 TU in Australia). It is true that the tritium/He method does not require the tritium input function to be known. However, unless piston flow is assumed, MRTs still have to be calculated via lumped parameter models (or some model that allows dispersion and mixing within the aquifer to be accounted for). The tritium input function in Brisbane (adjacent to Stradbroke Island) is well known (Tadros et al., 2014) and this is not the major uncertainty in calculating MRTs. Another important point is that the 3H/He method is sensitive to He degassing (during sampling or in the aquifer which is unconfined). Analysing the total He and differentiating its sources (excess air, terrigenic) from He derived from tritium decay is not without problems. Being able to analyse low level 3H bypasses all those non trivial complications. More pragmatically, the analyses were conducted at ANSTO via funding specific to that facility and there are low-level tritium but not tritium/He capabilities available.

Reviewer 2: L241: maybe better to use dissolved oxygen concentrations instead of ORP

Response: Both are indicators for reduced and oxidising environment. Our aim is to show the differences in redox potential and think ORP is adequate to use.

Reviewer 2: L245, 246: two decimal places really needed/valid?

Response: The two decimal places are not needed and we can round the number.

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Reviewer 2: L365: please avoid colloquial terms like “coffee rock”

Response: “Coffee Rock” is a common term for indurated sands with some organic content. It appears black and the term is used along the coast of South-East Queensland and northern New South Wales. The term was explained in the introduction of the text and we think it is adequate to use it in the conclusions.

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