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Dear Editor,

We have considered all the review comments carefully and revised the paper accordingly. The details of our revision and individual response (blue) to each comment (black) are attached. We appreciate the review comments, which led to significant improvement of the paper.

In addition to a clear copy of the revised manuscript (Luo_et_al_manuscript_R2.docx), we have included in the resubmission a marked copy (Luo_et_al_manuscript_R2_M.pdf) with changes highlighted. Line numbers provided in our response to the comments correspond with the marked copy (Luo_et_al_manuscript_R2_M.pdf).

Thank you for considering our manuscript for possible publication in *Hydrology and Earth System Sciences*.

Yours sincerely,
Jun Kong

Responses to Referee #1's comments

The manuscript investigates the impact of aquifer geometry on seawater intrusion in annulus shaped aquifer typical for islands using analytical solutions based on the Ghijben-Herzberg solution and hillslope-storage Boussinesq equation. The analytical solutions are validated by comparison with data from laboratory experiments, and then used to investigate the interface under different geometries (convergent, rectangular, divergent). The results are interesting and give some insight in the role of aquifer geometry on the seawater-freshwater interface. I have a few comments the aquifer as described in the following.

We thank you for the constructive and helpful comments.

Comments:

line 145: "interface tip" and "tip location" should be defined.

The term "interface tip" is defined as the location where the freshwater-seawater interface connects to the *z*-axis (Figure 2b) or the bottom boundary (Figure 2c) (Lines 241-242). we have indicated the interface tip in Figures 2b and 2c. In addition, to make it clearer, we changed the term "tip location" to "*x*-coordinate of the interface tip" (e.g., Lines 243, 410 and 450).

line 168: The underlying assumptions should be clarified here.

The underlying assumptions are Darcy's law and the Dupuit-Forchheimer approximation. We have mentioned these assumptions in Line 332.

Eq. (3): Different symbols phi should be used in the integrand and integration limit. What is phi in the upper integration limit?

Since ϕ is not the variable of integration, the same symbol can be used. In fact, ϕ in the upper integration limit is the watertable height. Because the integrand is independent of the integration variable, *z*, Eq. (3) is simplified, as now presented in the revision.

Eq. (6): Some more explanation is required on how this equation is obtain and what are the assumptions.

To obtain equation (6), the Dupuit-Forchheimer approximation and the Ghijben-Herzberg equation are used. Based on the Dupuit-Forchheimer approximation, equation (4) becomes,

$$-\frac{1}{2}\left[\left(L_0+l_2-x\right)^2-\left(L_0+l_2\right)^2\right]N=-\left(L_0+l_2-x\right)K_s\left(\phi-h_c\right)\frac{d\phi}{dx} \qquad \text{(R1)}$$

Based on the Ghijben-Herzberg equation, we have,

$$h=\phi-h_c=\left(1+\alpha\right)\left(\phi-H_s\right) \qquad \text{(R2)}$$

Combining equation (R2) with equation (R1) gives equation (6). We have added this explanation to the revision (Lines 353-361).

line 292: The authors use the term “extent of seawater intrusion” repeatedly in the manuscript, but it is never defined. The authors should clearly quantitatively define, which are the diagnostics/observables that are used to assess aquifer vulnerability.
The term “extent of seawater intrusion” is defined as the location of the freshwater-seawater interface (Line 76). The interface tip location is thus an appropriate measure of aquifer vulnerability.

Responses to Referee #2's comments

Major problem of the present paper is the English language. Needs specific attention.
Thank you for the constructive and helpful comments. We have gone through the manuscript carefully to improve the written English.

I believe the main contribution of the present paper is the saltwater intrusion phenomenon regarding the geometry of the aquifer.
Yes, we agree with the referee.

The paper is based on analytical solutions and as it is mentioned in the paper analytical solutions for saltwater intrusion problems cannot incorporate complex factors.
Although analytical solutions cannot incorporate complex factors, their advantages are that they are computationally efficient, can be used as test cases for numerical models, and can reveal the explicit relationships between parameters that influence seawater intrusion. We have mentioned these advantages in Lines 78-105.

Page 7, lines 122-124 need more explanation.
As mentioned in the manuscript in Lines 191-197, this is because the longitudinal length is much longer than the lateral length for an atoll island in reality. This is also consistent with previous studies where seawater intrusion from the lateral side is negligible (Ayers & Vacher, 1986; Underwood et al., 1992; Bailey et al., 2009; Werner et al., 2017).

Page 8, lines 149-153. assumption (5) needs more explanation.
If recharge is larger than the saturated hydraulic conductivity, overland flow (which will appear following ponding) occurs and hence analytical solutions no longer apply. This explanation has been added to the revised manuscript (Lines 249-319).

Page 9, ω = $\theta(L_0+l_2-x)$ what is θ???? You used this symbol for the angle in previous text.
θ is the angle as shown in Figure 2a. The cited expression defines ω as the arc length.

Page 10, Eq. 6 needs more explanation. You mentioned substitution of Eq. 5 into Eq. 4. But Eq. 4 does not contain h. Did you solve Eq. 5 for φ??
To obtain equation (6), the Dupuit-Forchheimer approximation and the Ghijben-Herzberg equation are used. Based on the Dupuit-Forchheimer approximation, equation (4) becomes,

$$-\frac{1}{2}\left[\left(L_0+l_2-x\right)^2-\left(L_0+l_2\right)^2\right]N=-\left(L_0+l_2-x\right)K_s\left(\phi-h_c\right)\frac{d\phi}{dx} \qquad \text{(R1)}$$

Based on the Ghijben-Herzberg equation, we have,

$$h = \phi - h_c = (1+\alpha)(\phi - H_s) \quad \text{(R2)}$$

Combining equation (R2) with equation (R1) gives equation (6). We have added this explanation to the revision (Lines 353-361).

Page 14, the experimental scale is very small.

When conducting seawater intrusion experiments, a small scale is usually adopted to better control the experiments. For example, Liu et al. (2014) conducted seawater intrusion experiments using a sand flume with dimensions of 1.6 m (length) × 0.6 m (height); Badaruddin et al. (2015) conducted seawater intrusion experiments using a sand flume with dimensions of 1.17 m (length) × 0.6 m (height); Lu et al. (2019) conducted seawater intrusion experiments using a sand flume with dimensions of 0.55 m (length) × 0.32 m (height); Wu et al. (2019) conducted seawater intrusion experiments using a sand flume with dimensions of 1.3 m (length) × 0.339 m (height). We have mentioned that future experiments and field data are needed to further validate and facilitate the analytical solutions (Lines 763-765).

The authors have not considered important publications on saltwater intrusion such as:

Pool, M., & Carrera, J. 2011 A correction factor to account for mixing in Ghyben-Herzberg critical pumping rate approximations of seawater intrusion in coastal aquifers. *Water Resources Research*, *47*(5), 1-9.

Mantoglou, A. 2003 Pumping management of coastal aquifers using analytical models of saltwater intrusion. *Water Resources Research*, *39*(12), 1-12.

We have mentioned these important publications in the revision (Line 762).

References:

Ayers, J. F., & Vacher, H. L. (1986). Hydrogeology of an atoll island: A conceptual model from detailed study of a Micronesian example. *Groundwater*, *24*(2), 185-198. https://doi.org/10.1111/j.1745-6584.1986.tb00994.x

Badaruddin, S., Werner, A. D., & Morgan, L. K. (2015). Water table salinization due to seawater intrusion. *Water Resources Research*, *51*(10), 8397-8408. https://doi.org/10.1002/2015WR017098

Bailey, R. T., Jenson, J. W., & Olsen, A. E. (2009). Numerical modeling of atoll island hydrogeology. *Groundwater*, *47*(2), 184-196. https://doi.org/10.1111/j.1745-6584.2008.00520.x

Liu, Y., X. Mao, J. Chen, and D. A. Barry. 2014. Influence of a coarse interlayer on seawater intrusion and contaminant migration in coastal aquifers. *Hydrological Processes*, *28*(20), 5162-5175. https://dx.doi.org/10.1002/hyp.10002

Lu, C., Cao, H., Ma, J., Shi, W., Rathore, S. S., Wu, J., & Luo, J. (2019). A proof-of-concept study of using a less permeable slice along the shoreline to increase fresh groundwater storage of oceanic islands: Analytical and experimental validation. *Water Resources*

Research, *55*(8), 6450-6463. https://doi.org/10.1029/2018WR024529

Underwood, M. R., Peterson, F. L., & Voss, C. I. (1992). Groundwater lens dynamics of atoll islands. *Water Resources Research*, *28*(11), 2889-2902. https://doi.org/10.1029/92WR01723

Werner, A. D., Sharp, H. K., Galvis, S. C., Post, V. E., & Sinclair, P. (2017). Hydrogeology and management of freshwater lenses on atoll islands: Review of current knowledge and research needs. *Journal of Hydrology*, *551*, 819-844. https://doi.org/10.1016/j.jhydrol.2017.02.047

Wu, H., Lu, C., Yan, M., & Werner, A. D. (2020). Expanding freshwater lenses adjacent to gaining rivers through vertical low-hydraulic-conductivity barriers: Analytical and experimental validation. *Water Resources Research*, *56*(2), e2019WR025750. https://doi.org/10.1029/2019WR025750