Reviewer 2

General Comments： This manuscript describes the thermal effects of intertidal springs on coastal waters and the thermal sensitivity of these springs to climate change. Methods that used including hydrologic and thermal monitoring, groundwater tracers (temperature and radon), and numerical simulation methods. It includes an intensive work. The paper is logically clear, and the results are well discussed and explained. I have the following comments that needed to be further addressed.

Thank you for considering our manuscript and providing this overview of our study, which is a good summary of our work.

Comment 1: The application of thermal information to indicate groundwater discharge has been investigated for several years. A combination of Radon, thermal images and models are not creative, therefore, it is very important to state out what are the new findings of this work? The same, as you are combing several methods, it is better to present a more clear graph abstract or figure to show the function of each method in your study. What are their contributions in this work. The figure 2 in the current version is not that straightforward and kind of confusing.

We aren't sure if the reviewer's comment about combining radon, thermal images and models lacking creativity is (1) suggesting there are other studies that combine these methods (we reviewed the literature extensively and are not aware of any that integrate thermal sensing, radon analysis and numerical modeling) or (2) stating that merely combining these methods is not enough for a novel paper. If the latter, we agree. The novel and important contributions of this study relate to better understanding the present and future thermal (and to a lesser degree hydrologic) function of intertidal springs for warming coastal ecosystems (see L80). Nevertheless, we agree that the scientific narrative could be improved somewhat, and we will update the introduction, methods, and conclusions to better elucidate our key objectives, describe how our methods tie together, and emphasize the key outcomes of the study. We will also slightly modify the title to focus more on 'present and future thermal influence of intertidal springs in coastal ecosystems'.

*The comment in reference to Figure 2 is likely pointing out that the **overall** methodology is not clear in Figure 2 (which only focuses on the thermal image analysis). We will add a new figure that integrates all of our methodological approaches and shows the relationships between them.*

Comment 2: Based on your data, the influence on coastal waters in the study area should be discussed in details as this is your main research goal.

We are slightly confused by this comment as the influence of the springs on the coastal waters is described in sections 5.1, 5.2, and 5.4; indeed it is the focus of these discussion sections. Perhaps the reviewer is looking for more focus on coastal zone processes that would differentiate this from inland studies. We do mention tidal impacts on the thermal plume dynamics (section 5.1), tidal impacts on the energy exchange (5.2). Also, the ecosystem we focus on in section 5.4 is distinctly coastal. We will add additional text in section 5.4 on the influence of water

temperature on blue mussels (which clump with the Giant Irish Moss) at the study site and the implications for management in this Marine Protected Area.

Comment 3: Thermal sensitivity analysis is your another proposed research goal. As to sensitivity, you have to first clarify what this term represent in your study case? what is the difference from your model "sensitivity"? What do you mean by using this term? A factor analysis by indicating which factor is the most important to impact the thermal variation? Or is it a case to study the response of thermal change to the climate change? I am a little confused from your analysis. By the way, the data you proposed is within a short period, how this validate a long term prediction in many years?

Thermal sensitivity is a term used in aquatic thermal regime work to refer to the change in water temperature divided by atmospheric forcing (often a change in air temperature). We will define this term more specifically in the modified text. This is completely distinct from model sensitivity.

With regard to the short term vs. long term issue: numerical models in hydrology and hydrogeology often use data from a short period to calibrate or assess a model and then apply that model to forward model decades into the future under some downscaled climate scenario or scenarios. This is not unique to our study. Being able to reproduce seasonal groundwater temperature signals under seasonal forcing does indicate that our general thermal properties and model thermal response is reasonably established, particularly given the strong physical basis for SHAW. We will, however, add one sentence to our discuss on the differences between modeling seasonal and decadal groundwater temperatures (a key point in Kurylyk et al. 2015 HESS) and thus acknowledge the limitation of this work.

Comment 4: A model calibration figure should be better added to show the model accuracy with continuous time series data for the main variables.

We will add new text or a sub-table discussing a comparison between the measured/modeled groundwater temperature means and amplitudes.

Comment 5: Some of the cited papers are not well formatted, please check them carefully.

Thank you for noting this; we will fix all issues with in-text citations and associated references.

Comment 6: In line 141, why the spring discharge is assumed to vary linearly with the piezometer water table? Whether there is any basis to confirm the rationality of the hypothesis. If yes, please add the corresponding description.

This is just based on Darcy's law ($Q = kiA$). The piezometer water level indicates the groundwater head, and thus is a reflection of the aquifer-lagoon hydraulic gradient averaged across the tidal cycle. We will edit this text slightly to make this clearer.

Comment 7: How to use thermal image to determine spring discharge is always a challenge as the pictures are two dimensional and your discharge is a three dimensional volume. Meanwhile,

they are varied with time in every minute, and make it hard to say what you photoed can indicate more information in different hydrological period, like in the wet or dry season.

We agree with these noted challenges; please see our specific responses below.

Sub-comment 1) Please add your flying area of the drone into your location map. It can help you to show whether they are consistent with the Radon data and you know the drone has a limitation to cover large area within a short time period.

The flying area is not intended to be consistent with radon data. The reason for this is that the springs can only be found in the fractured sandstone on one side of the lagoon, whereas the radon data integrates the groundwater influence across the lagoon. Nevertheless, we will add the approximate flying area to a map in our revised manuscript as we do think this is a good idea that will help the reader visualize the process.

Sub-comment 2) In lines 275-280, three springs were selected to determine the power function relationship between spring discharge and thermal plume area for the lagoon. There are about 40 springs in this area. Are the three springs representative? In addition, are the three data points too little to yield the mathematical relationship between the two?

This is a very reasonable concern. Please see our response to reviewer 1, comment 9 to explain why more points are not possible. We will explain this in more detail and expand discussion on limitations in the revised text.

Sub-comment 3) In line 281, the area of the spring is evaluated based on the irregular clipping of the spring location on the thermal image. What is the standard of graphic clipping? What principles need to be followed?

We will add a few sentences to the supplement to describe our clipping process. There is no standard clipping approach in the literature, but the key point is to be consistent to allow comparison across the dataset.

Irregular clipping was conducted, where possible, to isolate two distinct thermal groups and the transition between them (the lagoon water, and the spring water). The main priority was to reduce interference from thermal groups with overlapping temperature ranges (e.g., foliage, shoreline). Rectangular cropping enables too many sources of thermal interference, which in several cases erroneously altered the calculated area.

Comment 8: In line 253, the 1-D subsurface heat and water transport model established in the study area includes a saturated area of 3-93m. Do you have a temperature distribution along the perpendicular cross section to show the area that is effected by the spring plume. This is important to support that why the authors only select the temperature data at the depths of 1m, 3m, 5m, 10.28m, and 15.24m in the numerical modelingapproach in response to the surface forcing (Fig. 10)?

The only groundwater temperature data we have are in the coastal piezometer and upland well as described in the manuscript. We do not have data revealing the temperature distribution down

to 93 m. We extend the model far below our depth of interest to remove any effects of geothermal heat flux as is common in such modeling, and will explain this in the revised text. The depths indicated here refer to standard depths to show damping and lagging (1, 3, and 5 m, Fig. 10b). The other depths (10.28 and 15.24) in Fig. 10b do give the appearance of being randomly selected, and thus will be changed to reflect time series at the calibration points to better justify the choice of depths.

Comment 9: In line 823, please change "Bottom row [(c) and (c)]" to " Bottom row[(c) and(d)]".

Thank you for catching this typo, which will be fixed in the revision.

Comment 10: In Fig. 4(a)-4(b), please add the corresponding scale bar or pixel size of the image.

Good point; this will be added in the revision.

Comment 11: In Fig 10(a), the precipitation data over the years is unclear and lacks units. Please modify it.

Thank you, somehow this must have got cut off during the image upload and manuscript compilation. We will fix this in the revised version.

Comment 12: The work is comprehensive, it would be a good work if the main research goal and methods, especially their connections, can be stated very clear through the paper.

Thank you. We feel that the modifications in response to concerns from both reviewers should help clarify the goals and methods of the study.