Interactive comment on "How significant is submarine groundwater discharge and its associated dissolved inorganic carbon in a river-dominated shelf system-the northern South China Sea?" by Q. Liu et al.

Response to Reviewer #3:

In presenting a large and comprehensive and somewhat complicated dataset on the quartet of Ra isotopes within the Pearl River Estuary and the Northern South China Sea, the authors make a useful contribution to the study of SGD. The general interpretation of the data is valid and the presentation of mixing models is useful. Meanwhile the discussion of the contribution of SGD to DIC is very important.

[Response] We are grateful that the reviewer valued this study.

I generally agree with the comments of reviewer number 2 in that the biggest issue is the end member problem, but this is a common theme across Ra studies.

[Response]: We have thoroughly addressed the issue related to the end-members in our response to the comments from Reviewer 2.

I believe this is an exciting contribution to the field, but there remain some items that seem confusing to me:

1. Why do the authors use the surface 223/228 ratio as the initial activity ratio for understanding upwelling, rather than the deep offshore 223/228 ratio if this is the source of the water?

[Response]: The $^{223}Ra/^{228}Ra$ ratio in the subsurface offshore water was lower than that in some surface water in the nearshore upwelling zone, suggesting that there are other sources supplying high $^{223}Ra/^{228}Ra$ to the nearshore upwelling zone in addition to the subsurface offshore water. These sources include neashore groundwater and sediment resuspension. Thus, in our study, we utilized the maximum $^{223}Ra/^{228}Ra$ AR of 0.06 in the upwelling zone to estimate the lower limit of the water age.

2. Quantification of SGD is hampered by the uncertainty in the endmember and therefore offshore SGD should not be quantified by a nearshore endmember but rather the Ra activity in offshore porewaters. However this data may be difficult to get.

[Response]: Again, as explained in our response to Reviewer 2's comments, this study only examined the nearshore SGD rather than the offshore SGD. We have further clarified this issue in the revised MS.

3. Meanwhile the uncertainty surrounding the desorption of Ra from sediments cannot be understated in a system with high suspended sediment concentration. Therefore the authors should describe the SSC and perform some desorption studies within the system.

[Response]: The suspended sediment concentration in the shelf water during our cruise ranged from 0.09 to 2.97 mg L^{-1}, averaging 1.42 mg L^{-1}. From Fig.6, we know that the release of Ra isotopes from particles into solution occurred in the estuarine mixing process and completed before the Pear River water reached the shelf. Therefore we assumed that there was no further Ra desorption from

suspended sediments within the shelf water. Even if these suspended sediments continued to release Ra in the shelf water, this contribution would be negligible. A back-of-the-envelope demonstration is given as follows. If ~2 dpm g^{-1} ^{226}Ra (maximum estimates, Moore and Shaw 2008) was completely desorbed, the desorbed ^{226}Ra would only increase the shelf ^{226}Ra by 0.28 dpm $100L^{-1}$, which would be equivalent to a Ra flux of 5.4×10^{10} dpm d^{-1}, or only 5% of the total Ra flux of the present study.

4. As stated by the first reviewer, the nutrient data seem to be extremely high. Given all of the uncertainty in the system surrounding endmembers, the authors should clearly state the assumptions in these numbers.

[Response]: As described in the MS, we averaged all of the high ^{228}Ra (> 400 dpm 100 L^{-1}) samples in 2008 and 2010 as the groundwater end-member. Note that such groundwater end-members would imply an underestimation of SGD because the higher Ra end-member in groundwater would reduce the SGD flux both in the three end-member mixing model and the Ra mass balance calculations.

In the revised MS, we added a statement that we used the minimum and average nutrient concentrations in the saline groundwater as end-members to get conservative estimates of SGD-associated nutrient fluxes.

5. How does the fact that there was a major precipitation event directly before the sampling influence the numbers? Is it possible that this is the cause of the discrepancies in the short-lived Ra data? In other words did the increase in fresh surface water dilute the short-lived Ra isotope concentration compared to offshore waters past the plume?

[Response]: We believed that the reviewer was questioning the effect of precipitation diluting short-lived Ra isotopes. In our study area, only one offshore area showed low salinity and low ^{224}Ra. As we know, Ra quartet have similar biogeochemistry behaviors, with the only difference of their half-lives. If low ^{224}Ra offshore is caused by precipitation, we would observe the same effect for other three Ra isotopes. However, ^{223}Ra ($T_{1/2}$ = 11.4 days) and long-lived Ra were enriched in this offshore area. In addition, our alkalinity and nutrients data in this offshore low salinity zone further supported that it was influenced by the Pearl River plume rather than the precipitation. More details were given in our response to comment 5 of Reviewer 2. Therefore, we think low ^{224}Ra offshore with low salinity is due to decay of this short-lived nuclide ($T_{1/2}$ = 3.7 days) rather than dilution by precipitation.

6. Given that DIC is so important to this paper (see title) the authors should at least briefly describe the DIC data rather than just referring to previous articles, especially considering that JGR is not open access.

[Response]: We have added DIC concentration in the groundwater and SGD-derived DIC flux in other articles in the revised MS.

7. The figures and tables are generally good, but I do not understand what the crosses (plusses) are in Figure 5. Did I miss something?

[Response]: Crosses represent the temperature and salinity data, as described in the revised Fig.5 caption.

8. The title is a little too long, can it be cut back

[Response]: The title has been cut back to “How significant is submarine groundwater discharge and its associated dissolved inorganic carbon in a river-dominated shelf system?”

References:

Moore, W. S., and Shaw, T. J. : Fluxes and behavior of radium isotopes, barium, and uranium in seven Southeastern US rivers and estuaries, Mar. Chem., 108: 236-254, 2008.