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Discussions

Interactive comment on "Hydrological dynamics of water sources in a Mediterranean lagoon" *by* C. Stumpp et al.

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The authors discuss the results of a case study focusing on deciphering dynamics of water flow in Koycegiz-Dalyan lagoon located in the southwest of Turkey on the Mediterranean Sea coast using environmental tracers (heavy isotopes of water: oxygen-18 and deuterium) and water chemistry. The study demonstrates usefulness of environmental tracers in obtaining better understanding of coastal ecosystems functioning, with emphasis on lagoon-type environment. Such ecosystems are often home to rare species and need proper management. The discussed study is a valuable contribution to the available literature on the subject and deserves publishing in HESS journal.

General comments:

The conceptual model of the studied system is missing. It should be presented in the introductory part of the manuscript (possibly at the end of section 2.1.), accompanied by the hypothesis(es) being tested in the framework of the presented study. In fact, from the presented material it appears that it should be two separate conceptual models, one for the dry and one for wet period. Presentation of such conceptual model(s) in the introductory part of the manuscript would put the experimental data subsequently presented and discussed in a proper perspective and would facilitate the reading.

I would encourage the authors to get more out of the experimental data they are presenting (see discussion below). Also, I cannot see in their data any definitive proof that groundwater component is indeed making discernible contribution to the water balance of the studied lagoon system.

Specific comments:

1. p7231, line 21 - in the coastal context 'increased marine water influence' is the most frequent but not unique response to the enhanced withdrawal of groundwater. Also, deeper lying groundwater of non-marine origin can be mobilized in such cases.

2. p7233, line 7 - it is not obvious which watershed the authors refer to. Only much later in the text it becomes clear that this is the watershed of Köycegiz lake.

3. p7233, lines 11-14 - please give numbers for water level fluctuations in Köycegiz lake. Are there any data for the flow rates of water in the Dalyan channel during wet and dry period?

4. p7234, lines 2-5 - is would be beneficial to provide a picture summarizing basic climatology of the study area from near-by meteorological station (monthly means of surface air temperature and rainfall amount). Skip the sentence starting from 'Although the region is controlled......" It is too vague and out of the scope of the manuscript.

5. p7234, lines 6-17 - it would be beneficial to enlarge the area shown in Fig. 1b to

include entire Köycegiz lake with its Sultaniye basin.

6. p7235, lines 11-17 - I would strongly recommend to give additional table showing the long-term monthly isotope and precipitation data for the Antalya station. Are the reported annual averages of delta(H-2) and delta(O-18)weighed or arithmetic means?

7. p7235, lines 18-22 - uncertainties of chloride and salinity measurements should be reported as well.

8. p7235, lines 24-26 - my favorite end-members would be slightly different - see comment No.14.

9. p7237, lines 1-2 - please give the elevation range of possible recharge area(s) for groundwater being exploited by the sampled wells. More detailed discussion of the apparent difference between the isotopic composition of groundwater and local (Antalya) precipitation would be in place here. I disagree with the general statement that the differences between dry and wet season at not significant. They are significant for some wells: GW11 (7.3 ‰ difference in delta(H-2)), GW18 (0.40‰ difference in delta(O-18)), GW20 (0.83 ‰ difference in delta(O-18)). The question of course arises what do they mean. If real, they would point to rather short residence time of water. But they could also indicate some problems in well construction. This has to be sorted out in the text.

10. p7237, lines 7-9 - are the isotope and chemical signatures of this hypothetical geothermal water contributing to Köycegiz lake known? Please report if this is the case. Also note that from stable isotopes alone you cannot make any statement about geothermal origin of a lake water (eventual geothermal signal in O-18 will be always hidden in the evaporation signal).

11. p7238, lines 6-8 - as seen in Table 1, the chloride content in GW11 actually varies with stable isotope content of water (lower delta values accompanied by reduced chloride concentration during wet period).

12. p7238, lines 11-15 - as reported in Table 1, sea water was collected only on the top (10 cm depth). Was any sample collected also close to the bottom?

13. p7238, lines 25-26 - see comment No. 10. Without information about isotope and chemical characteristics of the geothermal component it is hard to argue about its influence.

14. p7239, whole section 3.3, subsequent discussion and conclusions: I have a major problem with three component end-member mixing scenario proposed by the authors. The two components are obvious (outflow from Köycegiz lake and the seawater). But the third one, groundwater input, is highly questionable. I do not see any solid evidence in the data presented by the authors that groundwater is indeed contributing significantly to the water balance of the lagoon, neither in dry nor in wet season. If there are any other data/evidence that groundwater is indeed entering in significant amounts the lagoon, they should be presented and discussed at length in the manuscript. The key figures in the manuscript are Figs. 2 and 3. Figure 2a shows that during dry season essentially all lagoon data are plotting in delta(H-2)-delta(O-18) space on the mixing line between the seawater and the lake water (top) end-members. There is one clear outlier here (L14-top). It would be worth to check the numbers and eventually repeat the analysis. Spread of the data points towards the upper portion of the mixing line may stem from impact of evaporation going on within the lagoon. During wet season the situation is totally different (Fig.1b). Now majority of the data is grouped within tight cluster around the two other end-members: lake water (top) and local precipitation input. Also in this case the cluster of data points representing the isotopic composition of groundwater clearly stays away of the two-component mixing field. The outliers (L33(bottom) and the lake data: L13(bottom), L14(bottom), L05(bottom)) apparently represent 'memory' of the lagoon with respect to the preceding dry period. The position of seawater suggest that there is a very little, if any, contribution from this source during the wet season. The data point representing the bottom of Köycegiz lake is irrelevant because the Daylan channel is apparently too shallow to receive significant

contribution from this source. Now comes Fig.3 with the mixing triangles proposed by the authors. I would stay away of this scenario. For the dry period stable isotope data clearly point to two end-member mixing. If we draw a mixing line in Fig. 3a between the data points representing Köycegiz lake (top) and the seawater, we have two problems: (i) majority of the data points is positioned to the right of this line, and (ii) at the upper end of this line we have several points which are clearly above the line i.e. they show distinctly higher chloride content than that adopted for the seawater component, although with comparable O-18 isotope composition. The first problem is relatively easy to explain. During the dry period we have strong evaporation of water going on in the entire lagoon. So, the impact of evaporation on both delta(O-18) and chloride content has to be taken into account. Rough assessment suggest that during evaporation of an isolated water body an increase of chloride content by 10% due to water loss will be accompanied by the increase of delta(O-18) in the order of 2-3‰İn chloride-delta(O-18) space in Fig. 3a this would be an almost horizontal line along which the data points are dragged away of the mixing line, to the right. This is in fact seen in Fig. 3a. As to the second problem, I can offer the following explanation. It is apparent from Table 1 that highest salinities (and chloride content) were measured during the dry period in points L8 and L9 (bottom waters). As far as I could see in Fig. 1b, point L8 sits directly in the channel connecting the lagoon and the open sea. Unfortunately, no bottom sample was collected for the open sea. Then, if we accept that the bottom sample of L8 represents true seawater input during the dry season (and this is most reasonable assumption in view of possible density currents, etc.) than the position of seawater end-member in Fig. 3a should be shifted up vertically to the position of the two topmost data points. Now, essentially all data points would plot to the right of the modified mixing line. For explanation, see problem (i).

Summarizing, my favorite conceptual model for the system studied by the authors would be as follows:

A. During summer (dry period), with essentially no rainfall and high temperatures dom-

inating in the region, surface water from Köycegiz lake feeding the lagoon is predominantly lost by evaporation within the lagoon (some mass balance calculations would be welcome here). This creates favorable conditions for invasion of seawater to the lagoon, predominantly via bottom flow through the channel connecting the lagoon to the open sea. This water has specific chemical and isotope signatures (chloride content in the order of 24000 mg/L, delta(O-18) $\sim$ +1.3 ‰ delta(H-2) $\sim$ +8 ‰. Influence of this water can be traced up to the point L22 (Dalyan channel). Essentially entire lagoon is impacted by the seawater input. In my view, the two-component mixing would be the most appropriate option here, with two end-members: (i) the sea water as specified above, and (ii) Köycegiz lake represented by surface water sample. Note: eventual mixing proportions in different regions of the lagoon should be calculated rather from the chloride-delta(O-18) plot, after correcting the data points back to the mixing line. As seen in Fig. 2a, disentangling the evaporation effects from the mixing is practically impossible in this case.

B. During winter (wet period) the lagoon is 'flooded' by freshwater originating both from the increased input of Köycegiz lake (some numbers would be welcome here) and from the local precipitation (ca. 1 meter of rainfall is reaching the lagoon during wet season). There is essentially no evidence for seawater entering the lagoon (L8 has 'freshwater' isotope and chemical signatures, both at the top and at the bottom of the water column). The 'memory' of the dry season is seen only in very few places in the lagoon. The two-component mixing scenario would also apply for this season, this time with Köycegiz lake (top) and the local precipitation as two end-members. Because these two end-members are very similar in terms of their isotopic composition, while chloride contents are inconclusive (possible agriculture input by surface runoff), I would not attempt any balance calculations for this season.

I would conclude emphasizing once more that in my view, neither isotope nor chemical data presented in the manuscript suggest any discernible groundwater input to the studied lagoon system. Of course, the lagoon ecosystem depends indirectly on groundwater via the Köycegiz lake which is apparently groundwater dependent.

Technical comments:

Table 1. There is something wrong with the salinity units. Definitely they are not in (ppt) as indicated in the Table (ppt indicates the ratio of 10 to -12). Salinity can be measured either as electrical conductivity or as total dissolved solids (TDS) expressed in mg/L. From the numbers it looks that these are ‰:.. I would suggest to mark the top and bottom position for each sample: eg. L01T, L01B, etc. Please report filter depth for the sampled wells, if available.

Figure 1. Add the position of Antalya station in Fig. 1a. Enlarge the map in Fig. 1b to include entire area of Köycegiz lake. Make the labels of the sampling sites more visible (e.g. using white background). Indicate on the map the position of the sampling site representing Köycegiz lake.

Figure 2. Make the horizontal scale of higher resolution (step: one per mill). Label the outliers with codes allowing their identification in Table 1.

Figure 3. Modify according to the discussion above. Make the horizontal scale of higher resolution (step: one per mill).

Figure 4, 5. Modify according to the discussion above.

Include additional table (monthly data for Antalya station). Include additional figure with local climatology (mean monthly surface air temperature and precipitation data).

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 7229, 2014.