Response to the reviewers' comments (3) on HESS-2009-213

Dear Dr. Hrachowitz,

Your detailed comments and suggestion are appreciated. Below are our responses. Look forward to your further suggestion.

Sincerely,

Huade Guan
On behalf of the co-authors.

Specific comments

1) P7027, L19: Please indicate at what time scale recharge rate and chloride input rates can be dealt with as constant..

Discussion and actions

Yes, we should make it clear. CMB method gives an average recharge rates probably over several years, especially when it is applied with groundwater chloride concentration.

2) P7028,L6: The first method considered by who? Please also mention other methods.

Discussion and actions

By saying this, we meant that CMB is the first method to be checked when people are to estimate groundwater recharge. This is based on a review of recharge estimates in Australia. Based on a review by Petheram et al. (2002), of total 76 recharge estimate studies using 12 techniques in Australia, the CMB accounts for 1/3.
As the sentence is likely to lead to misunderstanding, we decide to rephrase it.

3) P7028,L12: Please add a reference for high spatial variability in coastal regions

Discussion and actions

We agree, and will do this in the revision.

4) P7030, L.4: Maybe consider calling it "Storage change ΔS" or similar instead of "net recharge Rn", in order to avoid confusion.

Discussion and actions

As the paper is to deal with the conditions for using CMB to estimate groundwater recharge, we prefer to using a term including "recharge". The quantity we are talking about can be regarded as the contribution of the catchment to the total mountain block recharge. This contribution joins to the regional mountain block aquifer. The storage change term is probably not appropriate. On the other hand, we also notice that net recharge has been used to describe vertical gross recharge – vertical discharge through capillary rise. The vertical discharge can be resulted from either vegetation ET (as Dr. Crosbie pointed out) or from groundwater table dropping. When net recharge is used in literature, it is often related to 1D point recharge-discharge processes. In our manuscript, we don't consider distributed point recharge, but the average recharge from the catchment. Using the chloride mass balance method (Eq 2), this is the quantity that we can only estimate over the mountainous catchment, where surface and subsurface lateral flow is often important. And this quantity has been termed simply "recharge" such as in Dettinger 1998.
Thus, we believe the term "net catchment recharge" is the most appropriate term we can think of for the quantity. Now that both you and Dr. Crosbie feels some sort of misunderstanding.

We will distinguish this "net catchment recharge" from "net point recharge" that is used in literature, in the revision.

5) P7030, L.7: Please clarify why an overestimation could occur. Are there other processes involved besides transpiration?

Discussion and actions

By saying this, we meant that part of direct-water table recharge can be discharged into the stream, decreasing the catchment contribution to the total mountain-block recharge. As you and the other two reviewers are concerned this sentence, we decide to simply remove it in the revision.

6) P7031, L1: Please justify the assumption that chloride concentrations are the same in base flow and recharge. Isn't this again a matter of the averaging time scale we are looking at? If so please indicate it.

Discussion and actions

We agree. We will clearly state in the revised manuscript that all quantities are evaluated as an average over a multiple-year period to avoid short-term variability. And this is what we meant, but we didn't make it clear.

7) P7031,L.9: Where and how is Ct for subsurface water transfer determined?

Discussion and actions

It is difficult to determine this term for subsurface water transfer. It is listed here to complete the conceptualization. We will expand the sentence "Generally, the CMB method is not applicable for a type III or IV catchment" with "because T and Ct is difficult to quantify, especially for subsurface cross-catchment water transfer".

8) P7031,L.11: Why does water O/I of type III and IV catchments have to be significantly larger than that of type I or II? Can water transfer not also include net water loss from a catchment?

Discussion and actions

You are right. As another reviewer also pointed out, the conceptual catchment types listed here do not cover all conditions exhaustively. We could make types III and IV represent the cases for both transfer gain and loss. However, in terms of our purpose to estimate net catchment recharge, only when these transfers impact stream concentration, they can influence using chloride O/I to estimate chloride equilibrium status. As both surface (measured at the catchment outlet) and subsurface transfers to other catchments, do not generally influence stream water chemistry of this catchment, we don't include them into types III and IV. We will make this clear in the revision.

9) P7031,L.20: If water flux and Ct are known, shouldn't it be possible to define them, beside precipitation, as second input and therefore allowing the use of CMB?

Discussion and actions

Yes, if we could quantify both Ct and T, probably for some surface water transfer cases. We will make this clear in the revision.

10) P7032,L.5: What about combinations of the six presented conceptual models? Wouldn't *for example a catchment with losing stream, water transfer and leaching (or any other combination) be thinkable?*

Discussion and actions
We agree that the six conceptual types do not complete to represent all natural conditions. We will make this clear in the revision, and explain why only the six are presented.

11) P7034,L.19: Was only one EC-Cl^- relationship used for the analysis or a different for each catchment? If only one was used please justify, as one would assume different underlying soil and rock chemistries.

Discussion and actions
The waters flowing through different geological area may have different ionic composition, and thus may influence the relationship between [Cl] and EC. However, it is very difficult to derive separate relationship for different geological area. The total 450 stream-water samples cover the area with various bedrocks (metamorphous shale and sandstone, and carbonate rocks). As in the mountainous catchment, the average time of streamwater in contact with bedrock in its flow history is very short, the bedrock effect should be very small. We decide to use a mean relationship derived from all 450 samples for the whole area. Similarly, White et al. (2009) recently use one [Cl] – EC relationship for the whole Murray River and its tributaries, in an area which is much larger than our study area.

In the revision, we will discuss the issue, and the uncertainty may be resulted from it.

12) P7035,L.15: "Although…" please rephrase sentence.

Discussion and actions
We will do it.

13) P7035,L.20: What are the other regression variables?

Discussion and actions
Actually, for regression, we only used precipitation, based on the correlation analysis. We notice that on this line, we said "climate variables". We should say "climate variable".

14) P7039,L.10: Please justify the range of 25-125 mg/l. Although the authors assumption that recent recharge water should show lower concentrations seems sound, the chosen range still seems somewhat arbitrary.

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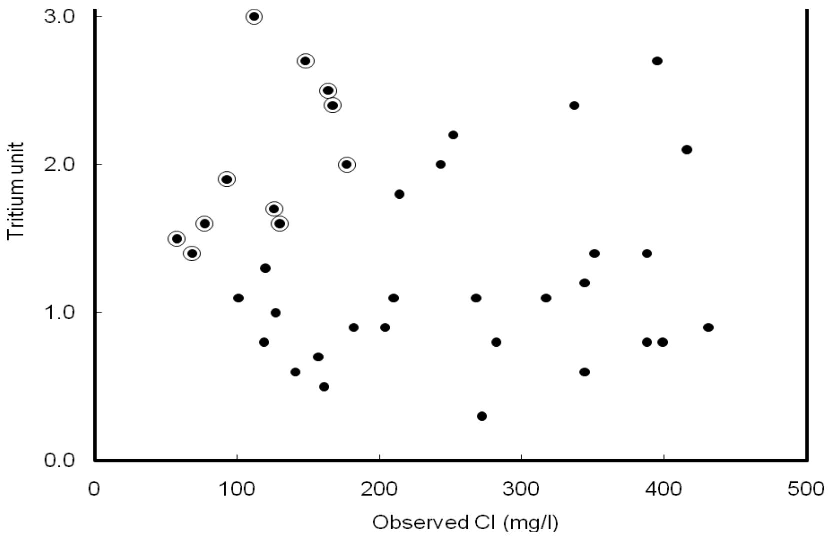
Discussion and actions
This range is defined as to the left of the mode in the histogram. We tried to use the tritium data to distinguish recently recharged water. It looks like



If the circled points (higher TU, but lower Cl concentration) are used for the mean chloride concentration, the geometric mean gives 110 mg/l. But the most dillute sample without Tritium measurement was not included in this calculation. If it is inlcuded, the geometric mean is 100 mg/l. But even this, we have to justify. Antoher mehtod currently in development, based on principal component analysis, gives a geometric mean of 90 mg/l. But the methodolgy is too complex to be inlcuded here. Nevertheless, the three methods come to similar mean groundwater chloride concentration, supporting the estmates based on the histogram.

We will give some justification in the rivision. And the geometric mean will be applied for calculating the mean, as suggested by another reviewer.

15) Table 1 and 3: Precipitation should always be reported as a rate. I suppose in this case the authors are referring to as mm/yr – please change units and indicate over which time scale this is the average (e.g. observation period or long term average). Same is true for streamflow and Cl load and deposition

Discussion and actions
It is revised as suggested.

16) *Figure 2: To ensure easier readability of the figure maybe consider removing the 1km DEM from the large figure as it does not any essential additional information.*

Discussion and actions
Figure 2 will be improved with your and others' recommendation considered.