Response to the reviewers' comments (1) on HESS-2009-213

Dear Reviewer,

Your comments and suggestion on the manuscript are greatly appreciated. Below are our responses. Look forward to your further suggestion.

Sincerely,

Huade Guan
On behalf of all co-authors.

Specific comments

(1) P7027 L12-14 It is expensive and needs representative sampling. It is difficult or not feasible in rock. Explain this more in details.

Discussion and Action
We agree, and will explain the difficulty in CMB application with soil chloride profile in mountainous areas.

(2) P7027 L16-17 This needs sampling the top of the water table. Penetrating and long screened boreholes and wells are often inappropriate. Explain this in detail. Using long-screened boreholes represent upstream recharge, but not local recharge. There is a paper being published on this.

Discussion and Action
We completely agree. When CMB is applied with groundwater samples, the samples should be the recent locally recharged water. Using long-screened borehole samples is not appropriate. The chloride concentration in such samples is often contaminated either by groundwater recharge from upstream as you pointed out, or by the post-clearance pulse release of soil chloride. In mountain terrain, the first mechanism often leads to overestimate of local recharge, and it is likely to be identified using stable H and O isotopes (Guan et al., 2009). The second mechanism often leads to underestimate of local recharge. This will be made clear in the revision.

(3) P2027 L18 This is theoretically inappropriate.

Discussion and Action
We assume you mean that CMB is applied in the 1D vertical flow field, and thus is not applied over a catchment. We think that the 1D assumption is rarely held in the hilly area, where the runoff and interflow can be very common. Thus, it is difficult to apply point-based CMB method, as we don't know how much atmospheric input of water and chloride becomes runoff and interflow, leaving this point. Thus, in the mountain terrain, it is more reasonable and feasible to apply the CMB on the catchment basis. As long as a precipitation distribution map and chloride deposition map are available for the catchment, the chloride input to the catchment can be calculated. Chloride output from the catchment by surface runoff can be estimated in the streamflow at the outlet point of the catchment. The rest chloride will be left in the recharged groundwater. This concept is demonstrated in Fig. 1.

(4) P2027 L25 Refer to removal time and depth to the water table

Discussion and Action

We agree to add the removal time. It is difficult to give an average water table here. But we will discuss the effect of water table depth on the timing for the system to move back to new equilibrium later.

(5) P7028 L6-7 Make it clear that the CMB gives average recharge over several years, not yearly recharge or event recharge. This is its importance and also its weakness.

Discussion and Action
We completely agree, and will revise as you suggested.

(6) P7029 L11-12 Explain this is to consider ungauged groundwater outflow or inflow from outside the basin. A cartoon on this will help in explaining the idea.

Discussion and Action
The water O/I is a reflection of water loss through ET. Yes, it would be also useful to indicate the cross-catchment water transfer. We will add a cartoon to explain both water and chloride I/O.

(7) P7029 Say that if there is not external contributions and losses, in equilibrium, O/I =1 for chloride.

Discussion and Action
We will explain this with a cartoon.

(8) P7029 L23 This has been extensively studied for the Murray-Darling basin with many chloride profiles showing what happens. This should be explained and mentioned.

Discussion and Action
We agree that some local research reports are missing from the reference list. We will explain and mention these studies in the revision.

(9) P7030 Comment on gaining and losing river circumstance and their relationship with respect to the gauging-sampling station.

Discussion and Action
All the gauging and sampling stations are at the outlet point of the examined catchment. The gaining and losing stream in our conceptual model is somewhat average condition for the whole catchment. We will make this clear in the revision.

(10) P7030 L7-8 Avoid this comment. That is …. or explain it more carefully. From the water management point of view, this is more complex.

Discussion and Action
We will rephrase this sentence, and avoid this comment.

(11) P7030 L11-13 Why event flow? Do you refer to occasionally flowing stream?

Discussion and Action
The term used here is to refer to the portion of stream water resulted from direct response to storm event. It is also called quick flow, storm flow, direct runoff, or storm runoff (Dingman, Physical Hydrology). Another portion of stream flow is base flow. We assume base flow is fed by groundwater.

(12) P7030 L11-13 Do you refer to average yearly recharge, point values,…, explain this correctly. Since there is no storage term, this refers to average recharge over a long term and the qe and ce are long-term average values. Comment on how to know the variation. P.Cp may differ from ∑(Pi Cpi), being Pi the value for a given Δt in which water is accumulated and since … Cpi.

Discussion and Action
All the quantities are mean yearly values. We will explain this clear in the revision.

(13) P7030 L24 How this split is carried out in practice? In the gaining station, both are measured together.

Discussion and Action
This is given for conceptual purpose. It is difficult to split in practice. Because of this difficulty, we cannot calculate direct water-table recharge, but only the net recharge using Eq. (2). We will clarify this issue in the revision.

(14) P7030 Is it needed to differenciate between R and Rn? Does this not complicate the paper if Rn is not used for O/I calculation.

Discussion and Action
We believe it is necessary to distinguish R and Rn, because they are two different conceptual quantities. One is the direct water table recharge (with phreatophyte transpiration effect included), the other one is direct recharge minus groundwater discharge via base flow. For a catchment without baseflow, R=Rn. For a catchment with baseflow, Rn<R. And it is difficult to calculate R because we don't know runoff and interflow. Rn is the quantity that can be calculated. Any CMB application with soil profile in mountains, is conceptually equal to R, but practically problematic, again because we don't know runoff and interflow. Hydrological modeling is probably the only way we can attempt to have an estimate of the runoff and interflow effect on both water and chloride, in the CMB calculation for R. In the revision, we will clarify this issue.

(15) P7031 L18-21 It is applicable if CR is measured in the unsaturated zone or in the top of the water-table aquifer.

Discussion and Action
We agree, and will rephrase it. This is actually the approach we took to estimate groundwater recharge for Catchment 7.

(16) P7032 L15 These are warning signals, but … CMB applicability is depend on Cl profile steady state and water-table water sampling.

Discussion and Action
Yes, if it is on basin floor, where local runoff can be neglected. On mountain terrain, the surface and vadose-zone lateral flow is common, we have to evaluate the chloride mass balance over the catchment, in which the lateral flow effect on chloride mass can be measured at the stream outlet point of the catchment.

(17) P7032 L23-25 This also depends on depth to the water table.

Discussion and Action
We agree, and will add some discussion in the revision.

(18) P7033 Under which conditions and sampling methods?

Discussion and Action
This is calculated with an assumption of a steady state condition. Both rainfall amount and chloride are measured. Groundwater sample at different screen depth intervals are measured. Apparently, the lateral flow component before the recharge is neglected in their calculation.

(19) About terminology of "direct recharge" and "diffuse recharge"

Discussion and Action
We use the term, *direct recharge*, for the groundwater recharge occurred from the unsaturated zone and from surface water body. It includes both diffuse recharge over the land surface, but also the focus recharge along the streambed or some local depression. We think it is better to represent the quantity we want to describe. This concept actually follows Mainzer (1923). Wilson and Guan (2004) has a review on various recharge concepts and terminology used in mountain terrains.

(20) Other minor comments and suggestion on Table and Figures

Discussion and Action
We all agree and will improve them. For Figure 1, we will add a cartoon before it. Hope this will make the figure easier to follow.