Point-by-point responses to Reviewer 1's comments:

Reviewer 1 Comment: 1. The authors have extensively reworked their manuscript and they have appropriately considered most my comments as well as the comments of the other reviewers. I believe the study is a nice contribution to potential use of CRNP data for water balance studies in arid environments. However, I have listed some minor remaining issues which should be considered. Therefore I can recommend the publication of this work after minor revision.

Author Response and Actions Taken: We appreciate the reviewer's positive assessment of the work and the modifications made based on the reviewer comments.

Reviewer 1 Comment: 2. My comment "P8L20-21" has not been resolved (Campbell (1990) is still related to the measurement volume of the Hydra Probe sensor). Thus the given estimate of the measurement volume of the sensor needs to be adequately referenced or removed. (Prior comment was "Statements in Campbell (1990) are not related to the measurement volume of the Hydra Probes used in this study.")

Author Response and Actions Taken: We are now utilizing the reference by Campbell (1990) to describe the measurement technique ("Individual sensors measure the impedance of an electric signal…") rather than the measurement volume. We have added a reference to Stevens Water Monitoring System (1998) for the measurement volume, specifically of the Hydra probe. We added the citation to the reference section: Stevens Water Monitoring System: Comprehensive Stevens Hydra Probe User Manual, 62 pp., 1998.

Reviewer 1 Comment: 3. Fig. 1 and 2 should be combined since both figures are redundant and the information (landuse, instrumentation, location) can be easily presented in one Figure.

Author Response and Actions Taken: We understand the reviewer comment, but prefer to keep Figure 1 and 2 separate since Fig. 2 contains detailed vegetation information that would be lost upon shrinking the maps to fit as sections (d and e) in Fig. 1. While Fig. 1 serves as our study area map to indicate locations and the instrument network, Fig. 2 has a different purpose related to the footprint areas of each sensor and the underlying distribution of vegetation and bare patches (as quantified in Table 1). Given the above, we do not see a dramatic redundancy. Since this is a stylistic preference, rather than a question of scientific content, we decided to retain our preferred approach.

Reviewer 1 Comment: 4. P19 L4: The term "channels with sandy bottoms" is not adequate. I think you are referring to "sandy channel beds".

Author Response and Actions Taken: We have changed this phrase following the reviewer suggestion.

Point-by-point responses to Reviewer 2's comments:

Reviewer 2 Comment: 1) In this study the soil moisture dynamics of two watersheds in Arizona and New Mexico were analysed. CRNS observation were validated through comparison with distributed sensors. CRNS observations were also compared to water balance estimates of soil moisture with some interesting findings. While there have been other validation type papers there are some new approaches applied in this paper that make it a valid contribution to the body of CRNS literature. I am not sure that the title entirely captures the papers contribution. It might be worth revisiting since your major restructuring efforts.

Author Response and Actions Taken: We thank the reviewer for the positive evaluation. We revisited the title in the revised manuscript by removing the discussion of the spatial variability of soil moisture and emphasizing instead the relation of soil moisture to evapotranspiration. The revised title: "Closing the Water Balance with Cosmic-ray Soil Moisture Measurements and Assessing Their Relation to Evapotranspiration in Two Semiarid Watersheds" captures well our contributions after the major restructuring.

Reviewer 2 Comment: 2) I have read the paper and the response to previous reviews and am satisfied that the authors have addressed all the required issues. There still seems to be some confusion around the applicability of the Desilets equation in an unmodified sense to volumetric soil moisture contents. Other authors have applied bulk density modifications which could have easily been applied here and which would then align the analysis more directly with the z* calculations. The correct application of techniques needs to be clarified in the CRNS literature. The restructuring has help to clarify the paper contributions and I see no major impediments to publication. I think this paper is well suited to publication in HESS. Comments of 3 previous reviewers have resulted in major improvements to this paper I can find no major flaws which will inhibit publications.

Author Response and Actions Taken: We appreciate the reviewer's positive evaluation. The issue regarding the Desilets equation should be clarified in the literature (given the uncertainty present in the original paper by Desilets et al. (2010)). We have made the suggested change to clarify this point (see response to comment below) to be in line with the reviewer concern.

Reviewer 2 Comment: P4L8: "…which is often used…"

Author Response and Actions Taken: We have made the suggested change.

Reviewer 2 Comment: P5L3: sentence starting on the line does not make sense, overlapping with the footprint of what?

Author Response and Actions Taken: We meant to say CRNS measurement footprint and have clarified as: "…in small watersheds that overlap with the CRNS measurement footprint…"

Reviewer 2 Comment: P5L7: "…each instrumented..."

Author Response and Actions Taken: We have made the suggested change.

Reviewer 2 Comment: P5L19: suggest delete after "scale", sentence is unwieldy

Author Response and Actions Taken: We do not agree that this sentence is unwieldy. While we could potentially divide into two sentences, this is a matter of stylistic preference. The sentence under question is appropriately written and clear.

Reviewer 2 Comment: P9L21: This equation is for gravimetric soil moisture not volumetric. Just need to say it is adjusted to include bulk density for achieving volumetric.

Author Response and Actions Taken: Desilets et al. (2010) refers to the calibration curve referring to either volumetric or gravimetric water content. We have treated the equation to refer to volumetric soil water. However, we have acknowledged the reviewer comment by modifying the text as: "θ (m^3/m^3) is volumetric soil moisture (adjusted from gravimetric content to account for the soil bulk density)…".

Reviewer 2 Comment: P11L4: Admittedly the hydrogen contributions from lattice water, biomass and soil carbon will be small and can probably be ignored in your case but I don't think the statement that they are implicitly accounted for in the calibration procedure is true (this may mislead others in different environments). The Desilets curve is for pure sand with no other hydrogen sources other than soil water. The effect I am talking about is shown in Zreda et al 2012 Fig 6 and associated text. If you are using your own calibration fit to observations and not fitting to Desilets then this can be ignored.

Zreda, M., W. J. Shuttleworth, X. Zeng, C. Zweck, D. Desilets, T. Franz, and R. Rosolem (2012), COSMOS: the COsmic-ray Soil Moisture Observing System, Hydrol. Earth Syst. Sci., 16(11), 4079-4099, doi: 10.5194/hess-16-4079-2012.

Author Response and Actions Taken: We agree with the reviewer comment and have deleted the following sentence to avoid confusion: "In addition, since a local calibration was performed, lattice water, biomass, and soil organic carbon are implicitly accounted for in the calculation of volumetric soil moisture from the calibration relation."

Reviewer 2 Comment: P16L8: rearrange sentence as it is grammatically incorrect

Author Response and Actions Taken: We agree that this sentence was too long and contained too much information. We have separated the ideas into two sentences and corrected them grammatically: "Nevertheless, there is an indication that θ_{CRNS} has a tendency to dry less quickly during some rainfall events (i.e., overestimate soil moisture during recession limbs). This might

be due to landscape features such as nearby channels (Fig. 1) and their associated zones of soil water convergence that remain wetter than areas measured by the distributed sensor network."

Reviewer 2 Comment: P17L2: illustrative of what?

Author Response and Actions Taken: We agree that this sentence might not have been clear. We have modified as: "The comparison of the semiarid sites is also illustrative of the ability of the CRNS method to estimate soil moisture over a range of conditions."

Reviewer 2 Comment: P22L1: abbreviate to CRNS

Author Response and Actions Taken: We have made the suggested change.

Reviewer 2 Comment: P24L4: Last sentence need to be rewritten as it makes no sense.

Author Response and Actions Taken: We agree that the last sentence could have been confusing. We have clarified as: "In term of the ET-θ relation, the CRNS method has the potential to significantly improve land-atmosphere interaction studies since it possesses a measurement scale that is commensurate to the sampling area of the EC technique."

Reviewer 2 Comment: Figures: In general, some of the line colors are hard to differentiate (e.g. Fig 3, 9) . Can distinct colors be used?

Author Response and Actions Taken: In the interest of utilizing the minimal number of color figures, we would prefer keeping non-color figures for Fig. 3 and 9. In both cases, we have used gray scales and/or line types (solid, dotted, dashed) to identifying lines properly.

Point-by-point responses to Reviewer 3's comments:

Reviewer 3 Comment: The authors have significantly improved the manuscript, both in the readability and in the clearness. I am overall satisfied of the answers to the comments so I believe the paper can be considered accepted for the publication.

Author Response and Actions Taken: We appreciate the reviewer's positive evaluation.

Reviewer 3 Comment: Table 4: It would be more correct to add the statistical significance along with the correlation coefficient.

Author Response and Actions Taken: We believe that the four metrics shown (RMSE, CC, B, SEE) provide a robust evaluation of the relationships between the variables. We interpret the 'statistical significance; mentioned by the reviewer to be the coefficient of determination (or R2) which measures the dispersion from a linear regression. This is effectively conveyed by the RMSE for the linear regression between the two variables and the SEE for the dispersion from the perfect relation (1:1 line) between the two variables. For these reasons, we have retained the four metrics and excluded the suggested fifth metric (R2) which can be derived easily from the CC since $R2 = CC^2$ (i.e. correlation coefficient raised to the power of 2).

Reviewer 3 Comment: Pg 20 line 8: "2000" should be "(2000)"

Author Response and Actions Taken: We have made the correction.

Point-by-point responses to Reviewer 4's comments:

Reviewer 4 Comment: This manuscript has been improved considerably. The authors have re-organized the structure of the paper so it now appears more clear to readers. In addition, I am very satisfied with author's explanation on the assumptions and simplifications when using the N0 equation without explicitly accounting for the lattice water (while later clearly explained why lattice water is needed when calculating z*).

Author Response and Actions Taken: We appreciate the reviewer's positive evaluation.

Reviewer 4 Comment: They have justified the land cover characteristics of the SRER based on previous studies (although I still keep my comment that Figure 2 in the new version does not support that - notice yellow patches for SRER and lack of those in EC tower footprint, similarly notice purple patches for JER and lack of those in EC tower footprint).

Author Response and Actions Taken: We recognize that some confusion might arise when comparing Fig. 2 and Table 1. In Fig. 2, there are multiple shrub species (mesquite, creosote, other shrubs) that are individually mapped, while Table 1 aggregates these into a single category ('shrubs'). This was performed to be able to compare across the two sites when each had different shrub species. We have clarified this in the table caption by adding: "Note that individual vegetation species have been generalized into three functional types."

Reviewer 4 Comment: Finally, I suggest the authors to modify the following sentence:
"To our knowledge, soil moisture estimates from the CRNS technique have not been used to study the hydrological processes occurring in small watersheds overlapping with the measurement footprint or for improving the parameterization of land surface models."

To: "To our knowledge, soil moisture estimates from the CRNS technique have only been recently used to study the hydrological processes occurring in small watersheds overlapping with the measurement footprint or for improving the parameterization of land surface models (Shuttleworth et al., 2013; Rosolem et al. 2014)."

Rosolem, R., Hoar, T., Arellano, A., Anderson, J. L., Shuttleworth, W. J., Zeng, X., and Franz, T. E. (2014) Translating aboveground cosmic-ray neutron intensity to high-frequency soil moisture profiles at sub-kilometer scale, Hydrol. Earth Syst. Sci., 18, 4363-4379, doi:10.5194/hess-18- 4363-2014, 2014.

Shuttleworth, W. J., Rosolem, R., M. Zreda, and T. Franz (2013): The COsmic-ray Soil Moisture Interaction Code (COSMIC) for Use in Data Assimilation, Hydrology and Earth System Sciences, 17, 3205-3217, doi:10.5194/hess-17-3205-2013.

Author Response and Actions Taken: We have incorporated the suggested change, while accounting for another reviewer's comment on clarity for this sentence.