Referee Comment #1

Garcia and Tague present an interesting comparison of hydrologic partitioning in three catchments, reaching the conclusion that differences in landscape characteristics, specifically subsurface water storage, attenuates the role of climate in controlling ET. The paper is a nice example of how the timing and amount of precipitation interact with variable storage to control the fate of precipitation in mountain catchments and should be of interest to the range of observationists and modelers.

Although the authors focus on the implications for these three catchments, the take home messages potentially are applicable to a wide range of systems where the spatially and temporally explicit interplay between climate and landscape has the potential to result in different hydrologic responses in locations with similar mean climate.

Although I am generally supportive of the work, I do have a number of concerns and suggestions that I hope will focus the presentation.

Reply: We thank the referee for the supportive comments and have addressed the concerns and incorporated many of the suggestions below.

Shorten and focus conclusions to highlight key implications. The current take home points are somewhat buried, including both modeling issues (e.g. error introduced by absence of soil calibration) and broader science take homes (e.g. precipitation timing vs. storage interactions)

Reply: We appreciate this suggestion and have removed/moved text that is better suited to the discussion and restructured the conclusions to focus on the bigger take-home points. The conclusion now reads as follows:

We demonstrate how subsurface storage and drainage properties (AWC and parameters that control lateral redistribution) interact with climate-related drivers to influence ET in three western U.S. mountain watersheds with distinctive precipitation regimes. These watersheds reflect conditions found in many other western U.S. snow-dominated systems, where summer water availability is influenced by the magnitude of precipitation, timing of soil moisture recharge and spring temperature and its effect on snowmelt. We found that, for our three watersheds, estimates of longer-term average (15-year) watershed-scale ET vary across a range of physically realistic storage/drainage parameters. For all watersheds, the range in long term mean ET estimates across AWC estimates (e.g., mean ET at a high AWC versus mean ET at a low AWC) may be as large as inter-annual variation in ET, suggesting that the influence of AWC and drainage can be substantial.

Our results also point to the importance of lateral redistribution as a control on ET, particularly for CA-SIER. Only a few studies have emphasized the role of lateral redistribution in plot to watershed scale climate responses in the Western U.S. (Barnard et al., 2010; Tague and Peng, 2013). For the CA-SIER site, our model results suggest that there can also be interactions between AWC and hillslope to watershed scale redistribution as controls on ET. Lateral redistribution was less important for the CO-ROC, where summer precipitation was a more important contributor to annual ET values and the least important for the wetter OR-CAS site. Results emphasize that the role of subsurface properties, including both storage and drainage, will be different for different climate regimes.

These results have important implications both for predicting ET in basins where data is not available for calibration and for understanding and predicting the spatial variability of ET within a basin. AWC also affects the sensitivity of annual ET to climate drivers, particularly in the two more seasonally water-limited basins. Although the three watersheds show different responses of annual ET to these climate drivers, there are values of AWC that would eliminate these cross-basin differences. These sensitivities highlight the need for improved information on spatial patterns of subsurface properties to contribute to the development of science-based information on forest vulnerabilities to climate change. Improved accounting for plant accessibility to moisture has improved model-data ET comparisons in previous modeling studies at regional and global scales (Hwang et al., 2009; Tang et al., 2013; Thompson et al., 2011). With expected decreases in fractional precipitation received as snow with climate change (Diffenbaugh et al., 2013; Knowles et al., 2006), we might expect soil storage to play a more important role in providing water for forests in the future. Improved understanding of how climate and subsurface storage/drainage combine to control ET can enhance our understanding of forest water stress related to increased mortality (van Mantgem et al., 2009). Western U.S. forests show substantial vulnerability to drought, with declines in productivity and increases in mortality and disturbance in drought years (Allen et al., 2010; Hicke et al., 2012; Williams et al., 2013).Understanding these ecosystems' responses to primary climate drivers is of particular concern given recent warming trends (Sterl et al., 2008) and multi-year droughts (Cook et al., 2004; Dai et al., 2004). Identifying the physical conditions in which our ability to estimate ET is most sensitive or limited by knowledge of subsurface geologic properties helps to prioritize regional data acquisition agendas. Integrating results from recent advances in geophysical measurements and models such as those emerging from Critical Zone Observatories in the U.S. and elsewhere (Anderson et al., 2008) will be essential for analysis of climate ET interactions.

REVIEWER COMMENTS CONTINUE BELOW

The paper could and should be improved by explicitly addressing alternative explanations for the differences between the three catchments. For example, they vary significantly in size, elevation, and total precipitation and the differences between catchment responses plausibly could be explained by these factors.

Similarly, how do the specifics of climate across the three sites influence results? For example, what does PET look like across time and space for your study catchments?

Presumably, higher elevations in CO are always energy limited, while lower elevations switch are water limited. In contrast, CA and OR experience the seasonal pattern in energy vs. water limitation that is your focus.

Reply: Though text throughout the paper addresses how cross-site differences in physical characteristics are influencing the response of ET to climate, we have included an additional paragraph to the discussion (now third paragraph) to be explicit about how the range of responses we observe in model results are related to these characteristics:

The range of sensitivities of ET to climate in this study is a direct function of climatic and physical characteristics of the catchments presented in this study. For example, OR-CAS receives twice as much precipitation and spans a much lower elevation range than either CA-SIER or CO-ROC (Table 2). Because OR-CAS is considerably wetter, its sensitivity of ET to magnitude of annual *P* is lessened considerably. OR-CAS' lower elevations, and related mean winter temperatures, also result in smaller average snowpacks reducing the strength of spring temperature as an explanatory variable for ET. Differences between CA-SIER and CO-ROC largely reflect seasonal distribution of precipitation, and reflect the importance of summer precipitation in CO-ROC. While climate is the dominant factor, topographic differences are also important. As discussed above, topographically driven flowpath convergence in CA-SIER tends to increase sensitivity of ET to parameters that influence lateral drainage. This effect is less evident in the other two watersheds. We also note that CO-ROC is considerably larger than our other two study sites and, as such, includes significant fractions of other land cover including rock and meadow. We expect the different vegetation types to influence the response of ET to climate.

Abstract begins with winter-wet summer dry but CO-ROC receives 46% precipitation in growing season while other sites are much less. This is an important part of your paper but suggests using a more objective metric perhaps AET: PET to describe differences between supply and demand.

Reply: P and PET are averages of annual sums. The aridity index, P:PET, is a helpful summary metric for normalizing how water-limited the catchments are. We added these values to Table 2.

	CO-ROC	**OR-CAS**	**CA-SIER**
P:PET	**0.9**	**2.3**	**1.2**

On a related note, the introduction begins with Mediterranean climates, but CO is a cold continental climate; I'm not certain that OR is technically Mediterranean either.

Reply: We appreciate this point and have removed the two occurrences of 'Mediterranean' as a description in the text --in the first line of the introduction, and the last paragraph of the introduction.

The results section as written reads too much like a discussion with numerous references and comparisons other work, making it difficult to focus on the key points of this effort.

Reply: We have edited the results section to move some of the discussion of results to the discussion section, and in some cases remove text that is in the discussion already:

> **Moved to discussion:**
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> Among the predicted consequences of increased temperatures are an earlier start to the vegetation growing season (Cayan et al., 2001), and an increase in vapor pressure deficits and water demand (Isaac & van Wijngaarden, 2012).
>
> CA-SIER does not show a significant relationship between T_{AMJ} and ET because the effect of temperature is strongly dependent on the amount of snowpack the basin receives in a year (Tague & Peng, 2013), which is more variable than the amount of snowpack received in CO-ROC or OR-CAS. These results suggest that the dominant effect of warmer spring temperatures is earlier meltout of snowpack, which leads to more snowmelt lost as runoff and results in less net recharge. A mechanism we suggest for this loss of runoff is that soils are more likely to be saturated in spring months. Later into the growing season, increased ET demands will have depleted soil stores and throughfall/snowmelt will enter the soil matrix and be available for plant water use.
>
> **Removed: Thus warmer spring temperatures could potentially increase total annual ET through lengthening of the early growing season**

I suggest you either changing the term “soil AWC” or more clearly define it to include other potential water sources. There is a growing body of literature that suggests that soil storage alone is often not sufficient to represent available water in mountain catchments. There this is rock water, groundwater, mobile vs. immobile water, etc. You have an opportunity to broaden the discussion and awareness among the land surface/ hydroclimate modeling community of these distinctions with this work.

Reply: We agree with the reviewer that plants often access water beneath what is typically defined as soil. In RHESSys plant available water storage is not restricted to “soil” but can include sapprolite, and rock water – and water from groundwater flow. We agree that the terminology “soil AWC” is indeed misleading. We have revised this terminology throughout the text and included the following text to emphasize that storage occurs not only in the soil:

Previous studies have shown that plants access to stored water is a substantial contributor to summer evapotranspiration in semi-arid regions (Bales et al., 2011). Plant accessible storage includes both water stored in soil and in sapprolite and bedrock layers that can be accessed by plant roots (McNamara et al., 2011).

Addressing the above issues should not require large amount of work, but should help focus the paper on important take home messages by addressing and removing distracting aspects of the current presentation likely to distract a critical reader.

References

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Cayan, D. R., Dettinger, M. D., Kammerdiener, S. a., Caprio, J. M., & Peterson, D. H. (2001). Changes in the Onset of Spring in the Western United States. *Bulletin of the American Meteorological Society*, *82*(3), 399–415. doi:10.1175/1520-0477(2001)082<0399:CITOOS>2.3.CO;2

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