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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Combined impacts of current and future dust deposition and regional warming on Colorado River Basin snow dynamics and hydrology" *by* J. S. Deems et al.

Anonymous Referee #2

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Summary:

This is an interesting and well written study pointing toward a potential first-order effect on snowmelt and hydrology in the Colorado River basin. While this effect may be limited to a few regions around the globe, its possible impact in a basin as important as the Upper Colorado more than justifies this work, though hinting at other regions that may also be affected by this phenomenon would broaden the appeal of this paper.

Specific Comments:

1) p. 6241, lines 17-29, several sources are cited documenting the projected increase

in drought frequency and severity. It is asserted that this will increase the "expanse of desert regions." This argument is fairly well stated, but it would be stronger if it could be more direct – what are the sources of dust for the UCRB, and are these sources specifically projected to increase in extent? This is hinted at later in the paper (p. 6250, line 10-11), but to name the source locations and the references for projections for these regions would make this case clearer. It seems that Western U.S. dust sources are identified, but there are other sources as well (e.g., Yu et al., Science, 2012).

2) p. 6243, lines 1-7, new albedo decay curves are based on field work performed at a study site. This raises the issue of scale, which needs to be addressed. How large of a site are these new relationships based on, and how representative is that of the entire UCRB? What is the spatial variability of the albedo changes observed during the more recent dust deposition events? Since the new relationships for snow albedo appear to be applied uniformly (by modifying the VIC albedo decay factors) across the domain, this may be a concern in the validity of the approach.

3) p. 6246, lines 15-20, it is stated that there is no "a priori reason to suspect that the empirical solar radiation formulation would be any less valid under future climate conditions." While this may be reasonable, a recent study (Pierce, D. W., Westerling, A. L., and Oyler, J.: Future humidity trends over the western United States in the CMIP5 global climate models and variable infiltration capacity hydrological modeling system, Hydrol. Earth Syst. Sci., 17, 1833-1850, doi:10.5194/hess-17-1833-2013, 2013) identified a bias in future humidity estimates by the algorithm used in VIC, and since humidity is used by VIC in its estimation of solar radiation at the surface, this concern should at least be discussed.

4) p. 6250, lines 16-19, the hydrologic effect of dust deposition events is stated "in the near-term" to be of greater magnitude than climate forcing. This is one point that this manuscript should clarify. The dust deposition appears to be mainly a source of interannual variability in snowpack and hydrology – the case for a trend in dust deposition is asserted but does not seem to have been statistically demonstrated in the

observational record or convincingly projected in the future. While the two recent high-dust events in 2009 and 2010, and medium dust events in 2003-2008 shows a recent increase, the time scale is far too short to call it a trend. Climate impacts on hydrology, especially due to temperature, in contrast, are well documented in the observational record and robustly projected for the future. The paper does show evidence that changes from mid-1800s to present appear to be toward higher current dust levels, but the nature of that change (linear trend, step changes) or when any abrupt changes might have occurred, does not seem to be well established. The argument later (p. 6252, lines 13-30) that mitigation may be possible based on the sensitivities found in this work would still be valid. It may be better to frame this as an argument that there is a source of hydrologic variability due to dust deposition on snow that may be able to be controlled to some degree through land management to induce a trend to counter some of the effects of warming. That would avoid the confusion of recent dust events with long-term trends, especially in the observed period.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 6237, 2013.