Review of Wu et al., ACP, 2017 - Impacts of Aerosols on Seasonal Precipitation and Snowpack in California Based on Convection-Permitting WRF-Chem Simulations

This paper uses the WRF-Chem regional model at 4km resolution to attempt to diagnose the effects of aerosols from different sources upon temperature, precipitation, snowfall and cloud properties over the California region. Simulations are run for 10 months for two different years.

There are some interesting results, but there are also some issues that need addressing before publication. My main concern is whether the "CLEAN" low aerosol case has too few aerosols (see below), which would lead to overestimates of the aerosol effect. But there are numerous others listed below. There are also a number of grammatical mistakes – I picked out a few, but there are more. Hopefully these will be picked up by the proof reader.

Overall comments

Model setup – I'm a bit confused by the CLEAN case. Do you set all the lateral boundaries to zero for all aerosols? Or just anthropogenic ones? If it is all aerosols and there are no local sources then I would imagine this would soon lead to there being very little or no aerosol at all in the domain (local non-anthropogenic aerosol only?)? If so, then what does the model do in zero aerosol situations in terms of droplet activation (since this may be the case for regions near the inflow boundary)? It would make more sense to allow non-anthropogenic aerosols into the lateral boundaries, so that what comes in is more like a clean background case. Or is this what has been done? It should be made clear in the manuscript.

There is a comparison of the model to observations in terms of the meteorology, but not for the aerosl properties. Since this is key to the results, it would be good to give some details of the comparison of the aerosol properties to observations rather than referring to the previous paper.

It would be good to mark/list the observational sites that are used.

It mentions that there is no effect of aerosol upon ice in the model - can you discuss the potential impact of this? E.g., more aerosol might lead to more ice nucleating particles, which could affect snowfall/ice production, etc. Perhaps a sensitivity test could be done whereby the number of ice nucleating particles (INP) are enhanced. Is an INP scheme used, and if so which one?

Do the precipitation rates that are quoted include ice phase precipitation or just liquid? It would be helpful to try to separate the liquid and ice phase precipitation.

Is it really the case that the transported aerosol comes from East Asia rather than more local sources? E.g. there seems to be a region of high AOD in Fig. 4d close to where Los Angeles is. Since the

transported aerosol seems to be one of the biggest contributors the source regions for this should be examined more carefully. Wind arrows showing the mean flow are also needed for Fig. 4 (or Fig. 1).

What causes the fairly large increases in SWE NW of the mountains?

It would be good to comment on the fact that the anth+dust+tran effects do not seem to add up to total effects – i.e., the overall combined effect seems to be greater than the sum of the parts.

Line-by-line comments

Abstract – you should mention the study period before you start to talk about the results.

L37 – "snow water equivalent (SWE)," – it is never explained what is meant by this. It sounds like it is the accumulated amount of snow that has fallen to the surface expressed as mm of water equivalent. But over the time period is never given. Presumably it is over the whole study period? This should be explained more thoroughly in the text before it is used.

L238 – Does the CPC rain rate product include only rain (and not snow)? This should be mentioned for clarity.

L245 – "For SWE, daily 245 mean SWE simulations are compared with measurements collected at Snow Telemetry" – should this be daily accumulated measurements rather than a mean?

L251 – "Model data are sampled onto observational sites before the comparison is conducted" – This information needs to come before the results are discussed (and put in the caption too). Does it apply to all of the observational data? Where are the observational sites? They should be listed or marked on the map, or at least some information on how many there are and their distribution, etc.

L258 – "Therefore, the WRF-Chem model that we employ in this study is a reliable tool for examining the impact of aerosols on the seasonal variations of 259 precipitation and snowpack in California, especially over the Sierra Nevada"

The results show a good representation of the meteorology and precipitation/snow, but it is a bit of an extrapolation to say that this means that it can reliably be used for aerosol-cloud interactions. E.g. we don't know how well it captures the aerosol and how its interaction with clouds. Better to say that the model represents the meteorology in a realistic manner. Or move the sentence to after you have explained how WRF compares for aerosol in the next paragraph.

L283 – "Transported aerosols, including dust and biological aerosols from East Asia 283 (Creamean et al., 2013), are carried into the domain by atmospheric circulation and widely 284 distributed, with more over the central valley due to the trapping of aerosols by the surrounding 285 mountains (Fig. 4d)."

Is it really the case that the transported aerosol comes from East Asia rather than more local sources? E.g. there seems to be a region of high AOD in Fig. 4d close to where Los Angeles is. Since the

transported aerosol seems to be one of the biggest contributors the source regions for this should be examined more carefully.

Also, can you explain how you made these plots? E.g. are they from runs with just the particular emissions included (anth, dust, trans), or did you have to do some differencing between the CTRL case and the e.g. no transport simulation?

L305 – you don't talk about the effect on SWE here even though it appears stronger than for the ARI where you did discuss it.

L318 - can you elaborate on why there is less SWE due to ACIs? What is the proposed mechanism and do you have evidence for it? Is it related to their being less liquid precipitation (e.g. less raindrop freezing, smaller droplets and so less droplet freezing)? Or does precipitation here include that from snow/ice? It might be argued that the higher LWPs might allow more liquid water to become frozen giving more SWE. Later on (L408) you say that the extra clouds from the ACI effect lead to less surface melt and more SWE for the lower elevation regions – can you explain/show whether the precipitation (or other) effect dominate over the temperature effect for the mountain tops, but not the lower elevations?

Likewise, can you please elaborate on why the albedo decreases and why the surface temperature increases. Is it due to the lack of fresh snow so that there is more exposed aged snow (although , or perhaps there are regions with no snow at all (at the start of the season perhaps)?

L343 – "It is shown that 343 transported aerosols also reduce the precipitation through ACI (Fig. 12a),"

L432 – "the impact of 432 aerosols is to speed up snowmelt at mountain tops." – This sentence should be removed since it suggests that aerosol enhance overall snowmelt when actually they reduce the runoff overall. There is a small effect of speeding up the onset, but this has already been mentioned and does not need to be said again since it ignores the snowmelt reduction effect (through the precipitation decrease).

Conclusions/L441 – "Temperature: Dust aerosols warm the mountain top surfaces through ASI (0.12 K)," – would be good to say that the numbers in brackets are domain mean changes. Also, you should re-iterated the abbreviations ASI, etc. in the text at the start of the conclusions and refer to Table 4.

L468 – "Therefore, one of the important impacts of aerosols is to speed up the snowmelt at 468 mountain tops." Is this really one of the most important aspects? Since the effect on runoff then goes on to be dominated by the reduction in the precipitation. And you can't be sure how much effect the earlier snow melt is having on that – most of the effect could be coming from the precip reduction?

Tables/Figures

Table 3 – perhaps it is worth mentioning that these experiments use the CTRL aerosol emissions.

Fig. 1 – It would be useful to label the valley, big cities and other regions of interest in Fig. 1. Also, the colorbar is a bit strange since the colors around 150m and 600m seem to repeat.

Fig. 2 – it is confusing to say that the SWE is averaged over the time period since presumably it is the accumulated snow amount?

Fig.3 – should state the region being considered here and in the text – is it the whole model domain? It would be good to also use a dashed line for the model to help distinguish it for colorblind readers.

Typos

L230 – “in CTRL experiment” -> “in the CTRL experiment”

L233 - “in the northern California” -> “in northern California”

L235 – “while colder temperature is found” -> “while colder temperatures are is found”

L314 - "because aerosol effect" -> "because the aerosol effect"

L316 - "associated with ACI effect" -> "associated with the ACI effect"

L358 – “contributes to the increase (1.88%).” – “contributes to an increase (1.88%).” (since overall there is a decrease).

L484 – ”importance” -> “important”