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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A global model simulation for 3-D radiative transfer impact on surface hydrology over Sierra Nevada and Rocky Mountains" *by* W.-L. Lee et al.

W.-L. Lee et al.

gu@atmos.ucla.edu

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The manuscript nicely demonstrates how small scale effects (topography) propagate to larger scales, by running a General Circulation model and studying the effects over the Rocky Mountains. It has been hypothesized over and over that 3D radiative transfer effects might affect weather and climate, and this is one of the first studies which actually proof that. I recommend publication of the manuscript after consideration of a number of minor points. I had some troubles understanding some points and ask the authors to clarify those - in particular it should be possible to understand the current manuscript without having to read several of the papers referenced.

Response: Thank you for your encouraging comments. Below please find our responses.

Specific: page 31609, line 1: It is not immediately clear why changes in the upward flux should be insignificant while changes in the downward flux are significant; could you please explain?

Response: We have revised this sentence to "The impact of upward flux adjustment is normally insignificant and can be neglected in regional model simulations since the contribution from the upward solar flux, which is only a fraction of the downward flux associated with surface albedo, to the atmospheric heating rate is much smaller than the downward flux."

page 31609, line 10: It is not clear to me what is actually done. Somehow the surface albedo is adjusted - does that mean that an effective albedo is calculated to account for the effect of topography? Please explain.

Response: Yes. To make this statement clearer, we have revised the sentence in line 8 to "We can use the parameterization for 3-D radiative transfer to adjust the land surface albedo. . ." (See also the response followed.)

page 31609, equation (1): The equation for Frdir looks wrong at first glance, but looking up Lee et al (2011) reveals that it is actually correct and makes sense. From reading the current manuscript it was not clear to me that all fluxes are downward fluxes. I assumed e.g. Frdir to be an upward flux. Please explain so that one can understand the basics without referring to Lee et al (2011)

Response: To avoid confusion, we have added "downward" in lines 11 and 19. In addition, we have added a sentence to describe why Frdir is expressed in this form: "Frdir is assumed to be proportional to the direct downward surface solar flux because conventional plane-parallel radiative transfer schemes do not explicitly calculate reflected fluxes."

page 31610, line 8: Why are direct and diffuse fluxes treated separately? I guess to understand that one would need some information about the treatment of albedo in CCSM4: Are there actually different albedos for direct and diffuse radiation?

Response: Yes, the land model in CCSM4 provides albedos for direct and diffuse fluxes for the radiative transfer calculation in the atmosphere model. We have added a clause to explain this fact at the end of this sentence: "... diffuse-reflected flux, since CLM4 calculates albedos for direct and diffuse fluxes separately."

page 31610, line 22: should be "2f" (not 3f)

Response: Typo corrected. Thank you.

page 31611, line 5: Could you discuss the "cloud fraction" issue a bit more? It seems logical that the cloud fraction is increased over south-facing mountain slopes since the insolation in the 3D model is higher than in the 1D approximation which causes orographic convection. But it seems a bit contra-intuitive that the cloud fraction increase might be so large that the insolation is actually decreased compared to the 1D approximation.

Response: We appreciate the Reviewer's speculation; however, there is actually no contradiction. This issue is associated with the diurnal cycle of convection. The additional insolation due to the topography effect can trigger convection earlier than 1D simulation, and then the larger cloud fraction produced by including the 3-D parameterization can reduce total daily insolation. We have included additional sentences in the revised text.

page 31612, line 6: The statement about reduced solar flux below 2.5km is not really supported by Figure 4a: On average there is an increase at all altitudes, although the increase is smaller at low altitudes. Response: Following the Reviewer's suggestion, we have rephrased this sentence to "... lower than 2 km, while solar fluxes reaching the surface are also generally larger in the 3-D case, the magnitude of the increase is

smaller than higher altitude regions due to the shading effect..."

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 31603, 2014.