Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-50-RC2, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Satellite-based radiative forcing by light-absorbing particles in snow across the Northern Hemisphere" *by* Jiecan Cui et al.

Edward Bair (Referee)

nbair@eri.ucsb.edu

Received and published: 20 May 2020

Aside from the Data Statement section, the authors responded to my comments, but did not make changes to the manuscript addressing my suggestions in my Access Review. Given the preliminary nature of the Access Review, that's fine with me, but during this formal review stage I ask that my comments be addressed in the manuscript. I have provided a copy of the Access Review below.

Limitations:

In the manuscript, the authors have not addressed the problem of distinguishing be-

tween absorbers in the air and on the snowpack as stated by Warren (2013). Some of the regions examined have extensive air pollution. The MCD43C3 albedo product used relies on MOD09 surface reflectance which masks out snow when estimating aerosol optical thickness. Snow is difficult to mask, and the "dark and dense vegetation technique" used to estimate aerosol optical thickness (Vermote & Saleous, 2006) has shown errors over snow cover in the past that have supposedly been addressed (Vermote et al., 2002). However, one can still find errors. For example, MOD09 surface spectra sometimes show strong hook features over relatively clean fully-snow covered pixels in the visible wavelengths that are not present in the top of atmosphere reflectances and can only be ascribed to problems with atmospheric correction. I'm not suggesting that the MCD43C3 product is unsuitable, rather I'd like to see its limitations over snow discussed in the manuscript. Saying that "more [sic] in-situ observations and hyperspectral imagery are needed.." is not a sufficient response.

MYD10C1 does not use spectral unmixing; it uses the 2-band NDSI which shows high scatter when converted to fractional snow cover using Equation 5. Thus, the fractional snow cover filter used is an undiscussed bias in the approach, where LAP could be mistaken for non-snow objects and vice-versa.

Note that MODIS is a multispectral, not a hyperspectral sensor.

Exclusion of midlatitude mountains and other vast snow-covered areas in the Northern Hemisphere is substantial and should be stated in the Abstract. As Referee #1 and #2 both point out, the domain (non-vegetated & non-mountainous areas) and time periods (Jan-Feb) are limited. These limitations undermine global application (e.g. p3 l1 & p6 l2).

NB 5/20/2020

________________________ Access Review from 4/4/2020

Further discuss limitations

Consider addressing the challenges in measuring LAP stated in Warren (2013) directly, such as distinguishing between absorbers in the air and those in the snowpack.

Equation 5 when applied in the MOD10A1 product shows an RMSE of 0.227 and a positive bias of 0.11 (Rittger et al., 2013). These errors and biases are important because darker objects at visible wavelength in mixed snow-covered pixels (e.g. shadows and vegetation) can be misidentified as LAP.

Section 3.2.3

This basis for the snow grain size retrievals cites studies (Nolin & Dozier, 2000; Painter et al., 2013; Seidel et al., 2016) which use hyperspectral imagery at an more than order magnitude greater spatial and spectral resolution than a multispectral instrument like MODIS. The authors are relying on the albedo retrieval from a single MODIS band at 1.24 μm to estimate grain size. This approach has high uncertainty due to errors in albedo retrievals from MODIS. In a previous study, Pu et al. (2019) state the MAE is 71 μm or 3 times greater than in the studies cited above using hyperspectral instruments.

The previous two comments suggest why substantial correction factors for the remotely-sensed measurements (Section 4.3) are needed.

Section 4.1

The study area does not include most of the midlatitude mountains in the northern hemisphere. Snow and ice melt in these areas provides a valuable water resource to over 1B people worldwide (Barnett et al., 2005) and studies cited by the authors in the Introduction (Painter et al., 2012; Seidel et al., 2016) show this snow is heavily affected by LAP.

Data availability

No data statement is provided. Please see the ACP Data Policy which requires a statement of how the data can be accessed.

Barnett, T. P., Adam, J. C., & Lettenmaier, D. P. (2005). Potential impacts of a warming climate on water availability in snow-dominated regions. Nature, 438, 303-309. https://doi.org/10.1038/nature04141

Nolin, A. W., & Dozier, J. (2000). A Hyperspectral Method for Remotely Sensing the Grain Size of Snow. Remote Sensing of Environment, 74, 207-216. https://doi.org/https://doi.org/10.1016/S0034-4257(00)00111-5

Painter, T. H., Bryant, A. C., & Skiles, S. M. (2012). Radiative forcing by light absorbing impurities in snow from MODIS surface reflectance data. Geophysical Research Letters, 39, L17502. https://doi.org/10.1029/2012GL052457

Painter, T. H., Seidel, F. C., Bryant, A. C., McKenzie Skiles, S., & Rittger, K. (2013). Imaging spectroscopy of albedo and radiative forcing by light-absorbing impurities in mountain snow. Journal of Geophysical Research: Atmospheres, 118, 9511-9523. https://doi.org/10.1002/jgrd.50520

Pu, W., Cui, J., Shi, T., Zhang, X., He, C., & Wang, X. (2019). The remote sensing of radiative forcing by light-absorbing particles (LAPs) in seasonal snow over northeastern China. Atmos. Chem. Phys., 19, 9949-9968. https://doi.org/10.5194/acp-19-9949-2019

Rittger, K., Painter, T. H., & Dozier, J. (2013). Assessment of methods for mapping snow cover from MODIS. Advances in Water Resources, 51, 367-380. https://doi.org/10.1016/j.advwatres.2012.03.002

Seidel, F. C., Rittger, K., Skiles, S. M., Molotch, N. P., & Painter, T. H. (2016). Case study of spatial and temporal variability of snow cover, grain size, albedo and radiative forcing in the Sierra Nevada and Rocky Mountain snowpack derived from imaging spectroscopy. The Cryosphere, 10, 1229-1244. https://doi.org/10.5194/tc-10-1229-2016

Vermote, E. F., El Saleous, N. Z., & Justice, C. O. (2002). Atmospheric correction of MODIS data in the visible to middle infrared: first results. Remote Sensing of Environment, 83, 97-111. https://doi.org/https://doi.org/10.1016/S0034-4257(02)00089-5

Vermote, E. F., & Saleous, N. (2006). Operational Atmospheric Correction of MODIS Visible to Middle Infrared Land Surface Data in the Case of an Infinite Lambertian Target. In J. J. Qu, W. Gao, M.

Kafatos, R. E. Murphy, & V. V. Salomonson (Eds.), Earth Science Satellite Remote Sensing: Vol. 1: Science and Instruments (pp. 123-153). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-37293-6_8

Warren, S. G. (2013). Can black carbon in snow be detected by remote sensing? Journal of Geophysical Research: Atmospheres, 118, 779-786. https://doi.org/10.1029/2012jd018476

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-50, 2020.