Estimating Fractional Snow Cover Algorithms Using Exclusively Landsat Observations

Igor Appel

IMSG@NOAA/STAR

It is considered a standard approach to apply high-resolution observations to validate moderate resolution retrieval of the fractional snow cover on the basis of implementing the following specific steps.

- Binary classify high-resolution pixels as snow / non-snow
- Aggregate estimates within larger grid cells to reduce the effect of data spatial mismatch
- Use matched in time moderate-resolution and high-resolution scenes
- Exactly co-register data sets to make high-resolution and moderate resolution information completely comparable
- Compare snow fraction derived from high-resolution classifications with moderate-resolution snow fraction estimates.

Three last steps listed above involve processing moderate resolution data on the basis of a fractional snow cover algorithm to be validated. It requires extensive works on the algorithm implementation, and additional processing for validation. The comparison with Landsat data is complicated by different viewing and illumination conditions significantly complicating validation of the fractional snow algorithm under consideration.

The presentation describes an original paradoxical approach to validate moderate resolution retrieval without processing moderate resolution data. The essence of developed methodology is as follows.

The quality of sensor measurements is comparable for different sensors including both high-resolution and moderate resolution. It means that there is no principal difference between reflectances calculated from different sensors. However, the estimates of moderate resolution fractional snow cover retrieval quality are influenced to a large degree by varying viewing geometry of the moderate-resolution observations. To make the validation of the moderate-resolution fractional snow product more reliable the moderate-resolution observations from nadir are therefore preferable, but as was mentioned above these observations on reflectances are approximately equal to aggregated high-resolution data. It means that the high-resolution data (reflectances and ground truth snow fraction) are quite sufficient to validate and improve fractional snow cover algorithms.

16 Landsat scenes characterized by a wide variety of surface types and solar illumination conditions were taken into consideration to implement proposed approach. Usage of these high-resolution scenes excludes the influence of varying zenith angles from our analysis making results more representative.

The approach was tested at the example of comparison between two alternative fractional snow cover algorithms assuming linear relationships of snow fraction with (a) visible reflectance and (b) the Normalized Difference Snow Index (NDSI) using the analysis or regressions of ground truth snow fraction on both visible reflectance and NDSI. The comparison of two algorithms demonstrates obvious advantages of the optimal linear regression on NDSI (characterized by correlation coefficients of 0.95) when compared to the optimal linear regression on the visible reflectance (characterized by correlation coefficients of 0.85).

Further analysis indicates approximately 60% increase in the standard deviation for regression of the fractional snow cover on visible reflectance in comparison with the standard deviation for regression of the fractional snow cover on NDSI in the case when the intercept for the regression lines is set to zero (Figure 1). It means that the variance for the regression on the visible reflectance is twice larger than the variance for the regression on NDSI.

The uncertainty of the relationships under consideration is less than the 0.1 threshold in most cases for the regression on NDSI (Figure 2), but only in two Landsat scenes for the regression on visible reflectance (Figure 3). The worst quality of the regression on NDSI is characterized by the standard deviation of less than 0.12, but more than 0.20 for the regression on visible reflectance.

Concluding it is necessary to remind and to emphasize that the comparison above has been made for optimal linear relationships of fractional snow cover with visible reflectance and NDSI. However it is not clear how the realization of the visible band algorithm could be optimized and therefore practical retrieval based on the visible reflectance provides much poorer quality of snow fraction than described above. The scene-specific realization of the NDSI algorithm on the contrary is close to its optimal version and therefore could be preferable for snow fraction retrieval.

Appel, I. 2014. *Retrieval and Validation of VIIRS Snow Cover Information for Terrestrial Water Cycle Applications (Chapter 11),* in Remote Sensing of the Terrestrial Water Cycle, edited by Venkataraman Lakshmi, AGU, Washington, D. C. and Wiley, Hoboken, N. J., 756 pp.

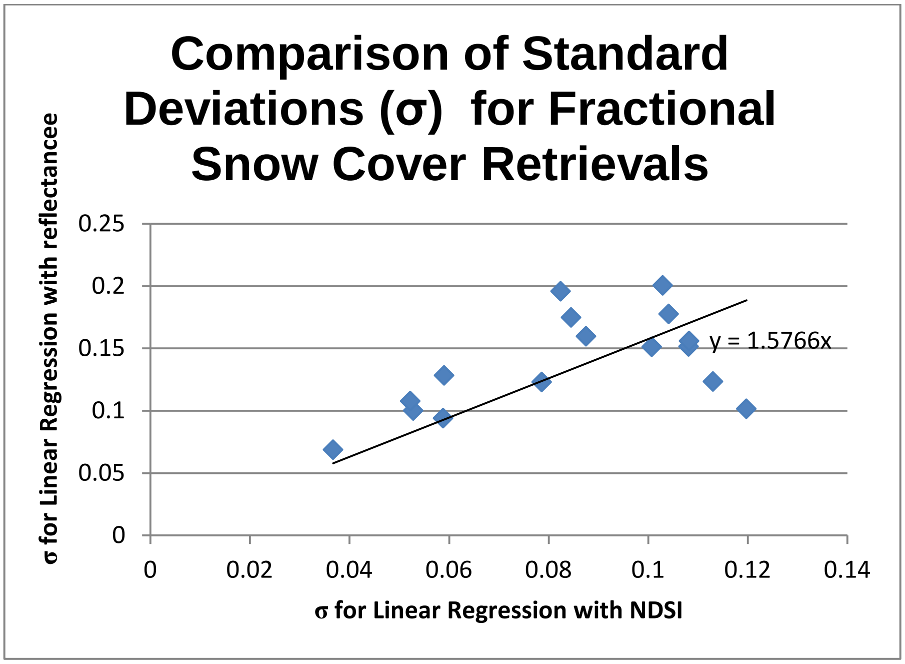

Figure 1

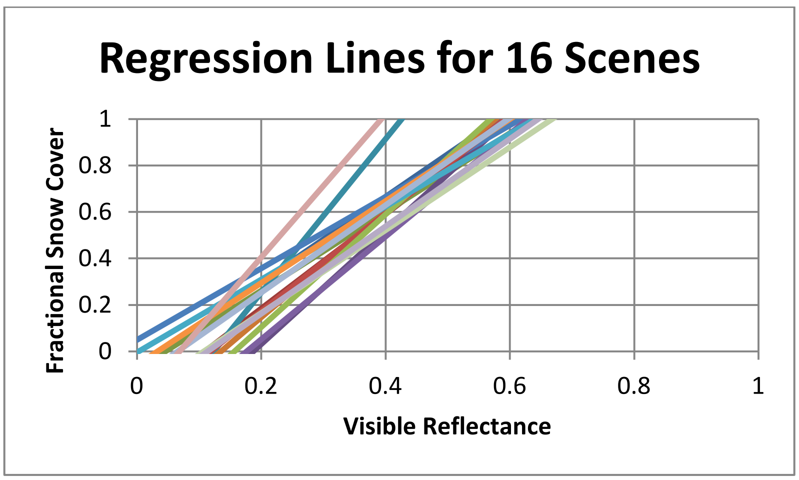

Figure 2

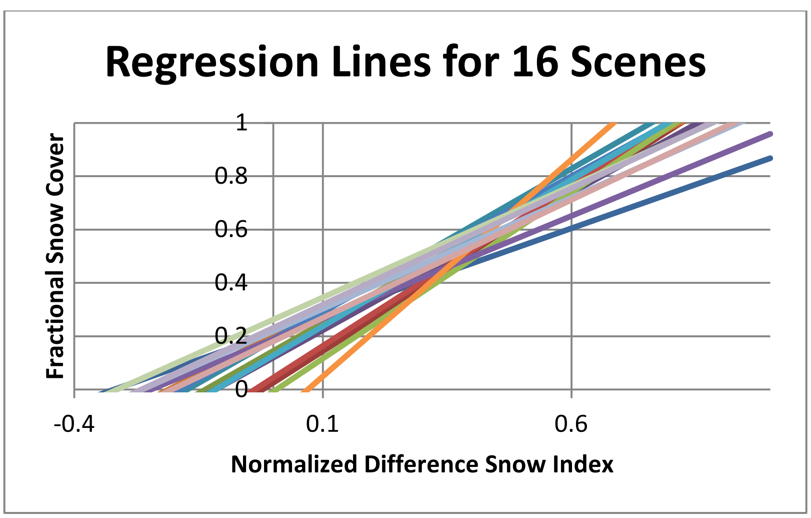

Figure 3