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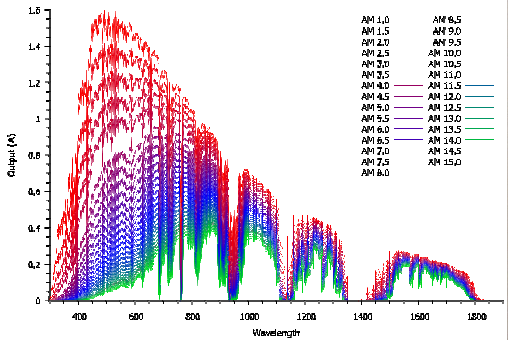

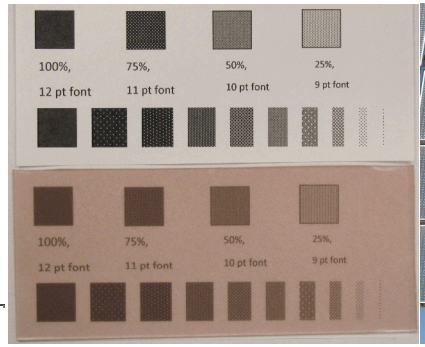

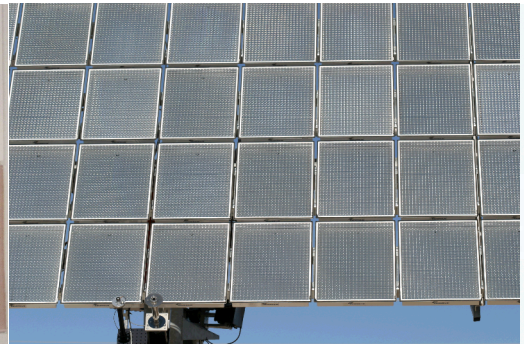

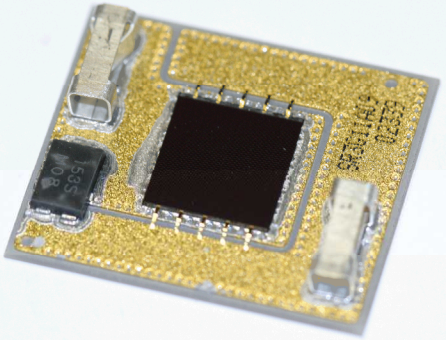

Predicting the Spectral Effects of Soils on Multijunction Photovoltaic Systems

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In preparation for submission to the *Journal of Renewable and Sustainable Energy*

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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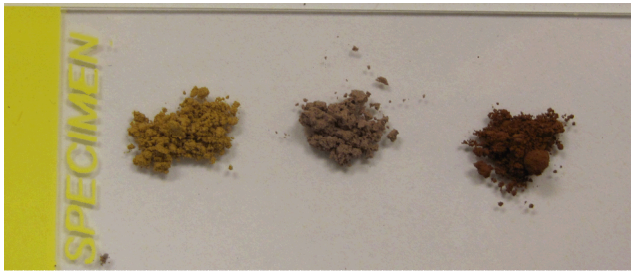
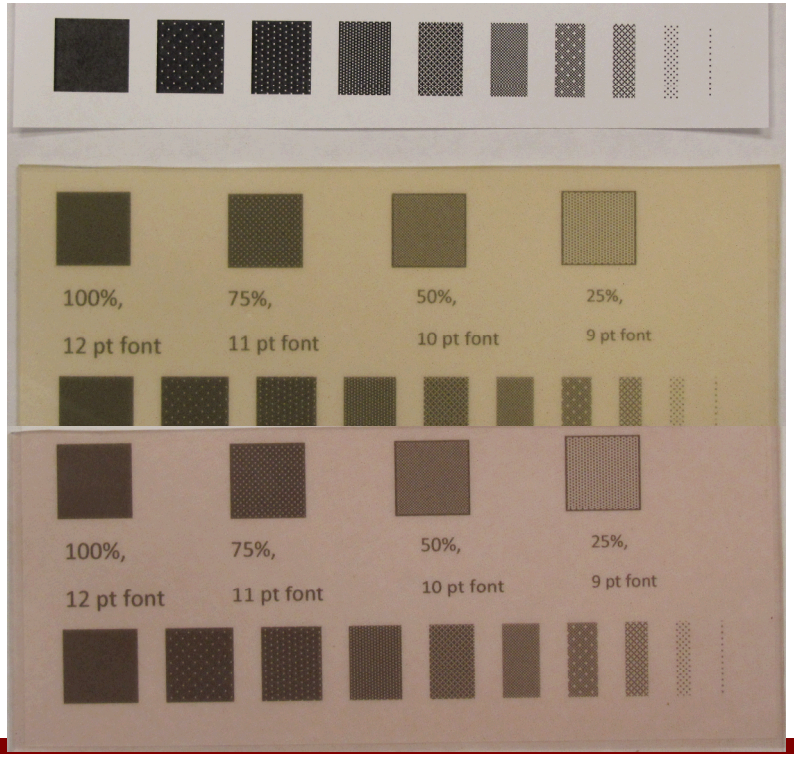
Multijunction photovoltaic devices may be sensitive to spectral alterations due to accumulated soil

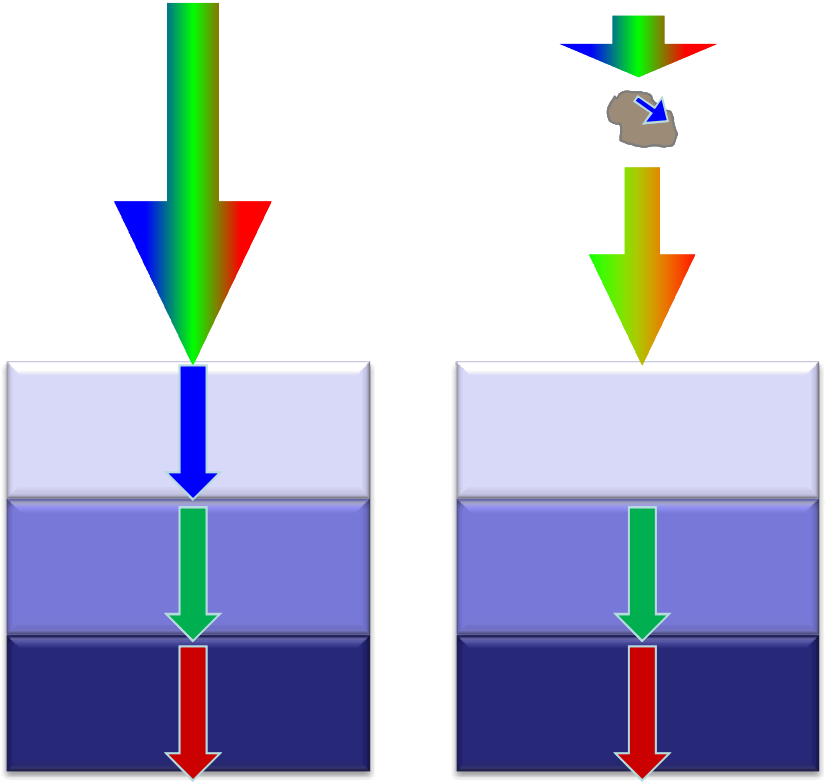


Soil composition influences the transmission of light

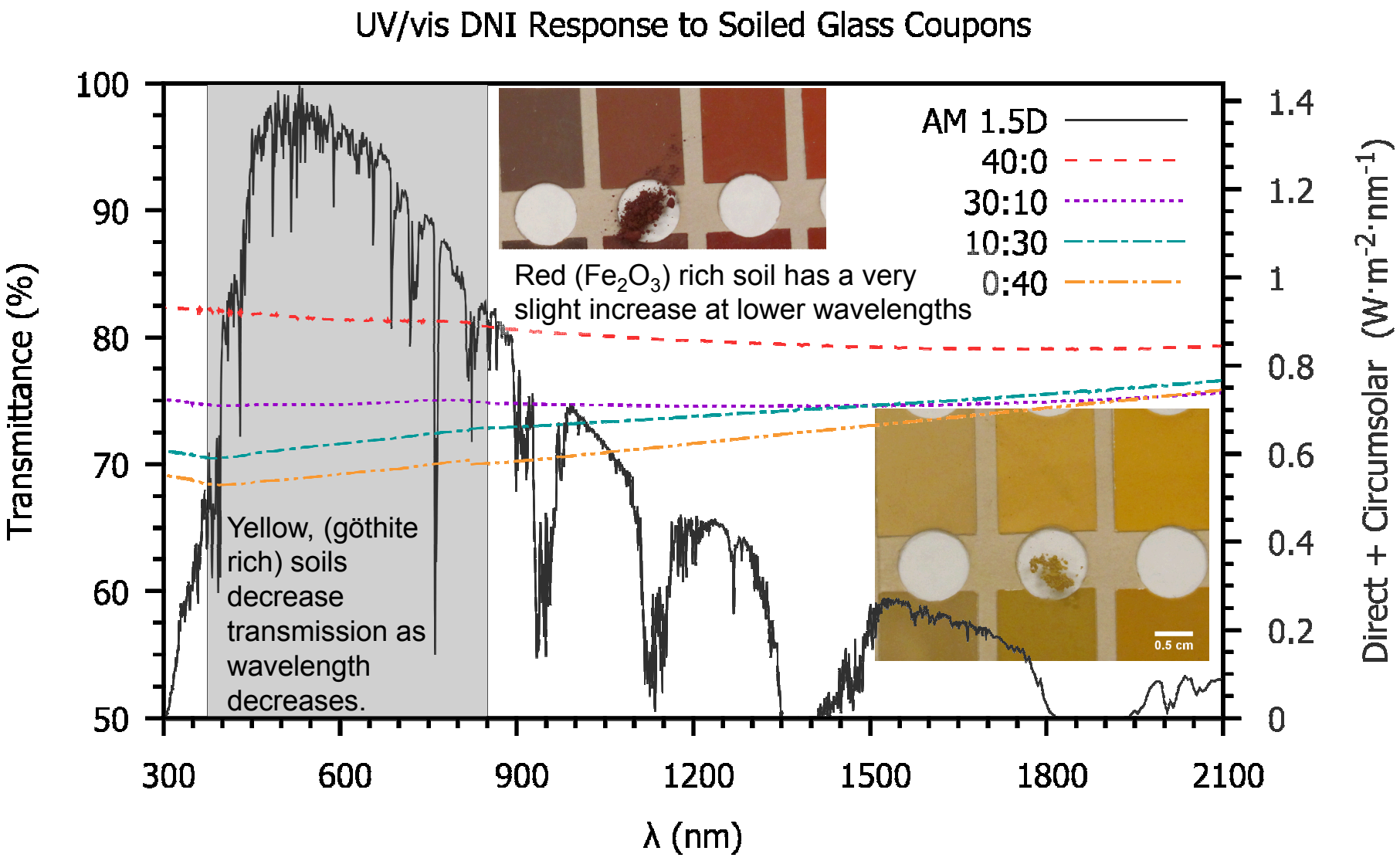


Multijunction cells are limited by the current of the lowest junction in series.

A small loss at a specific wavelength could cause significant decrease in overall performance.

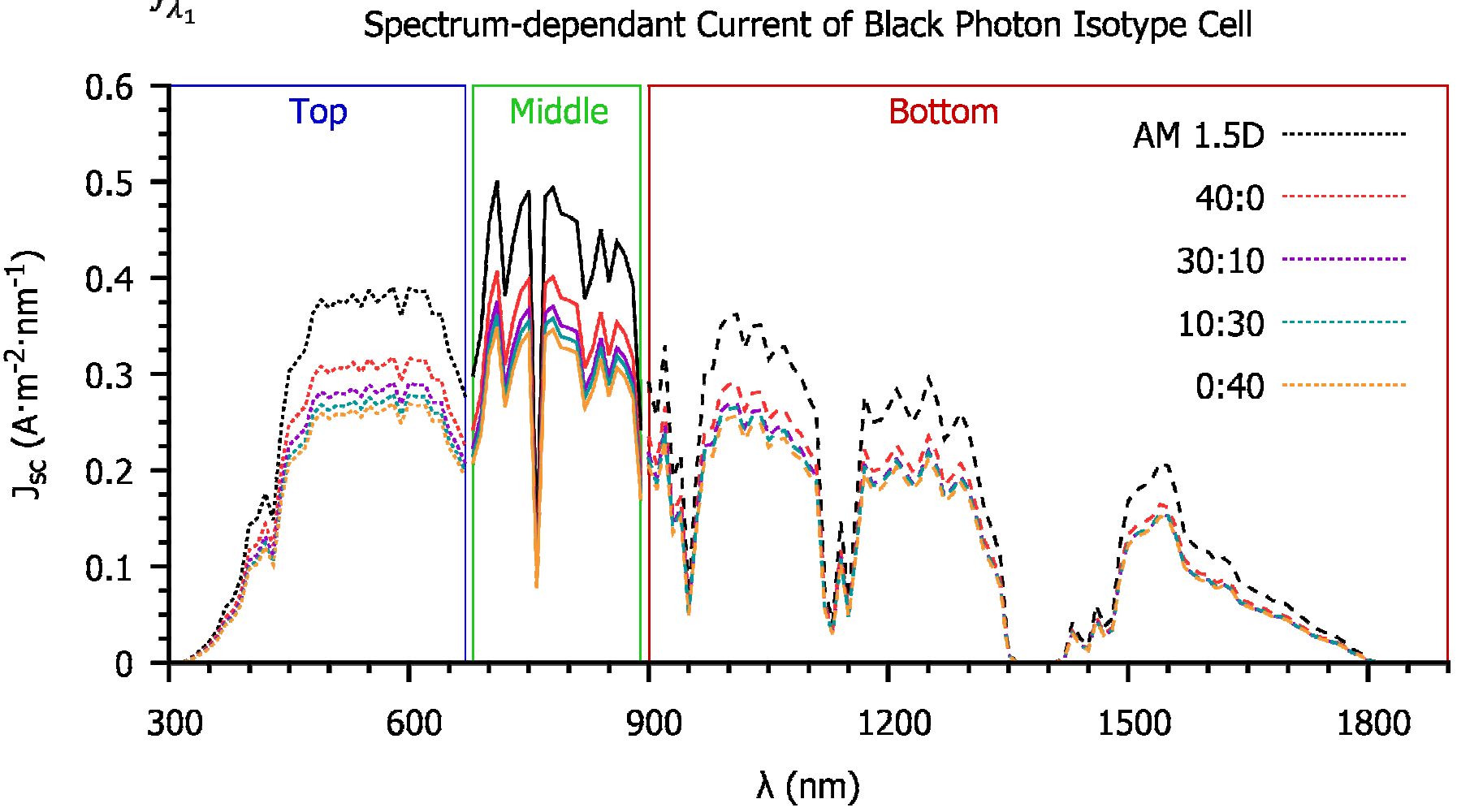


Common minerals can reduce transmission in the most energy-rich region of the AM 1.5D spectrum

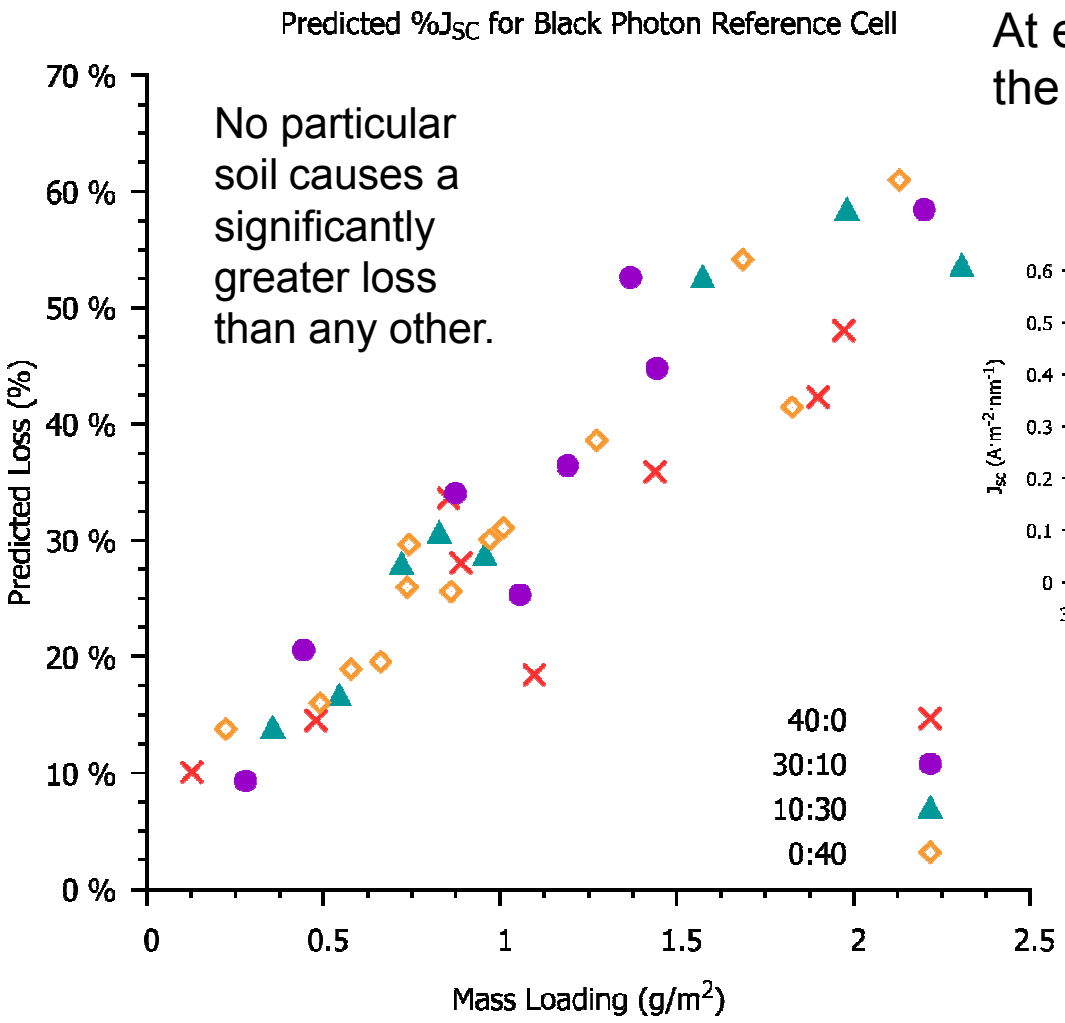


The effect of soil at each wavelength can be predicted by calculating J_{sc}

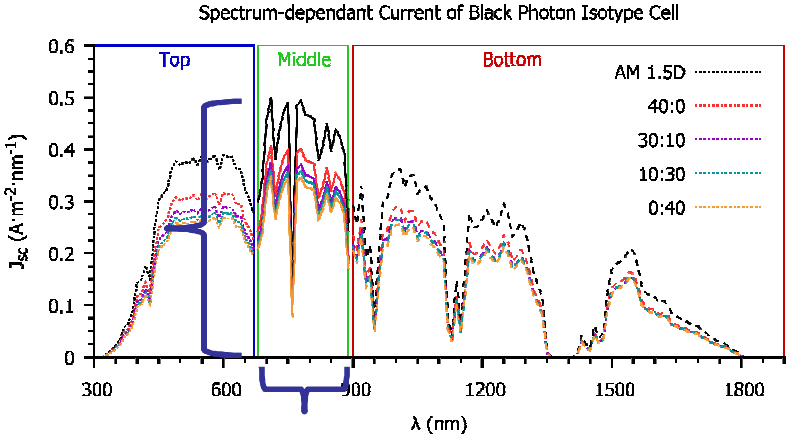
$$J_{SC} = \int_{\lambda_1}^{\lambda_2} \Phi_x(\lambda) \cdot SR(\lambda) \cdot \%T(\lambda) d\lambda$$



Predicted J_{sc} magnitude is independent of soil type at AM1.5D

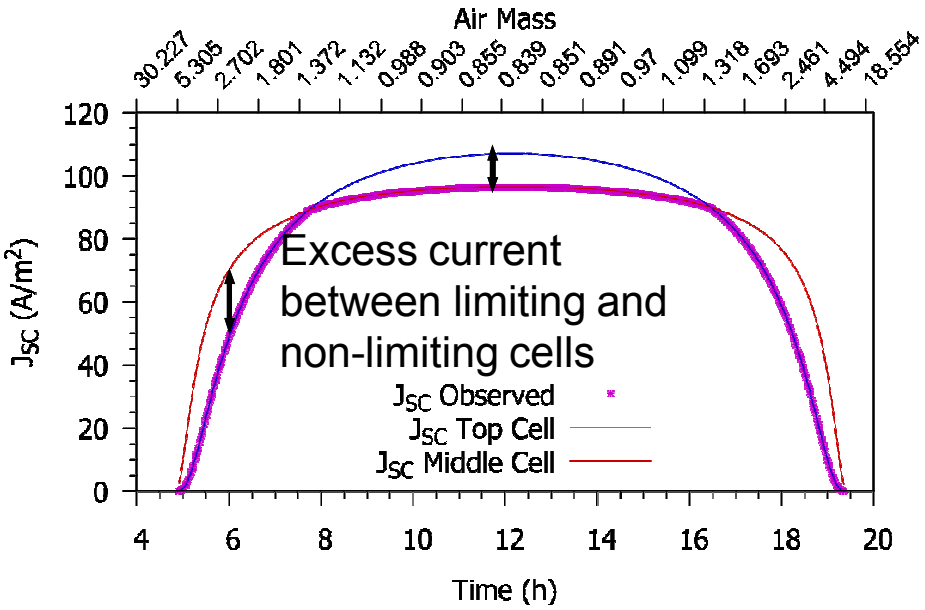


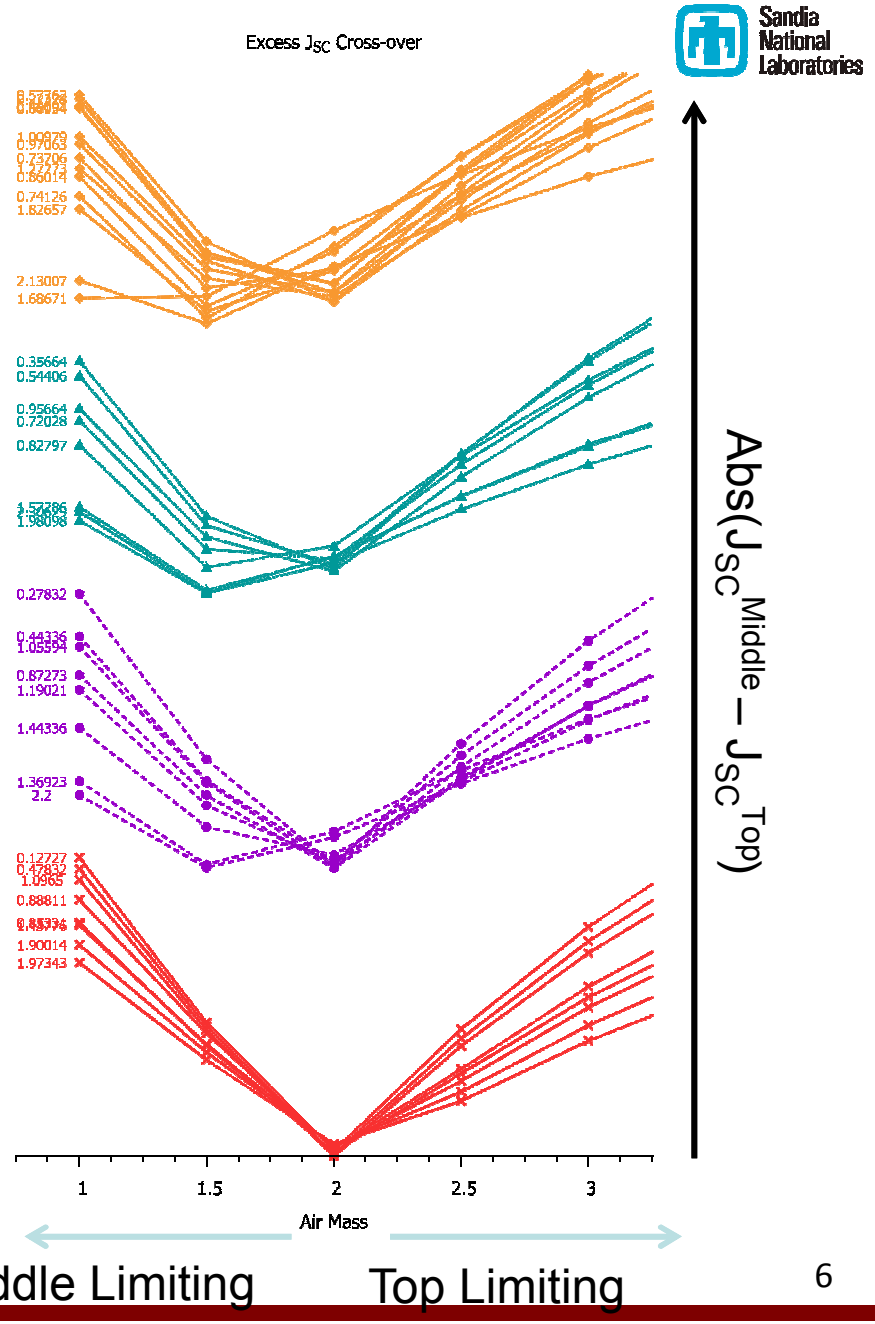
At each point, the middle junction is the current limiting subcell.



The area of the middle junction is small compared to the top. If the incident irradiation drops significantly, then the top cell would become the limiting junction.

Excess current is dependent on soil type

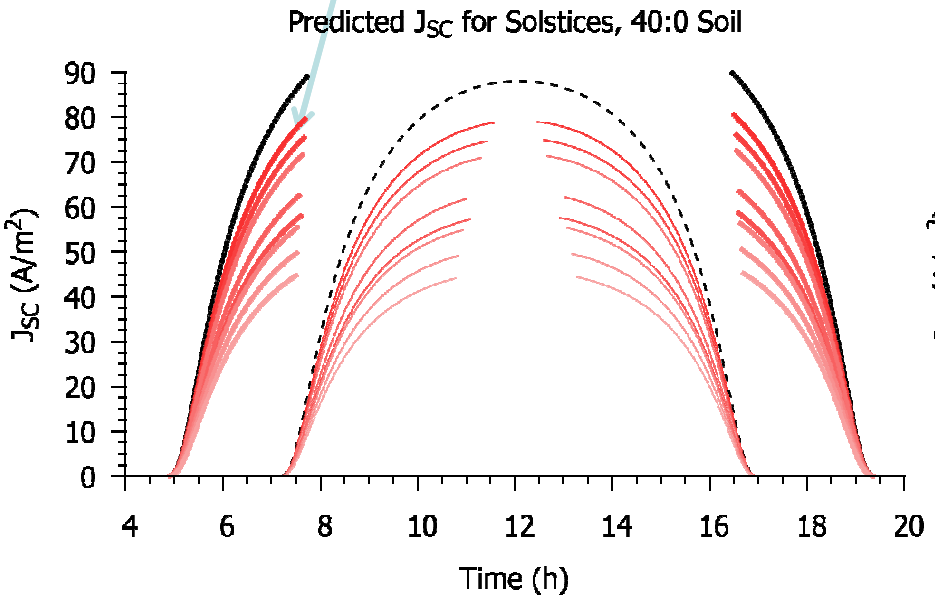


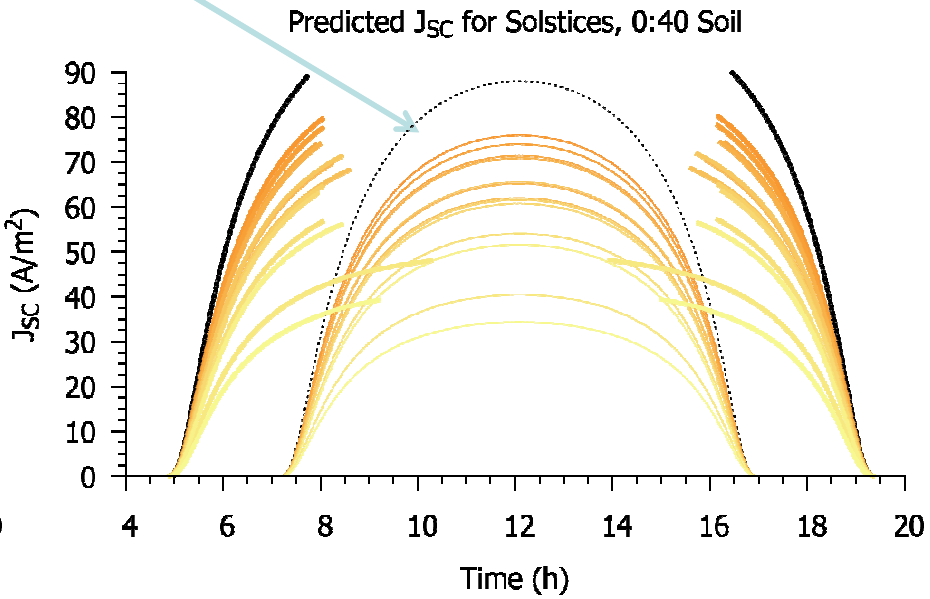


Red soils undergo consistent current switching behavior; Yellow soils are less uniform

Current limiting behavior varies over the course of a day and year with soil type

Summer shown in thick lines, winter shown in thin lines.



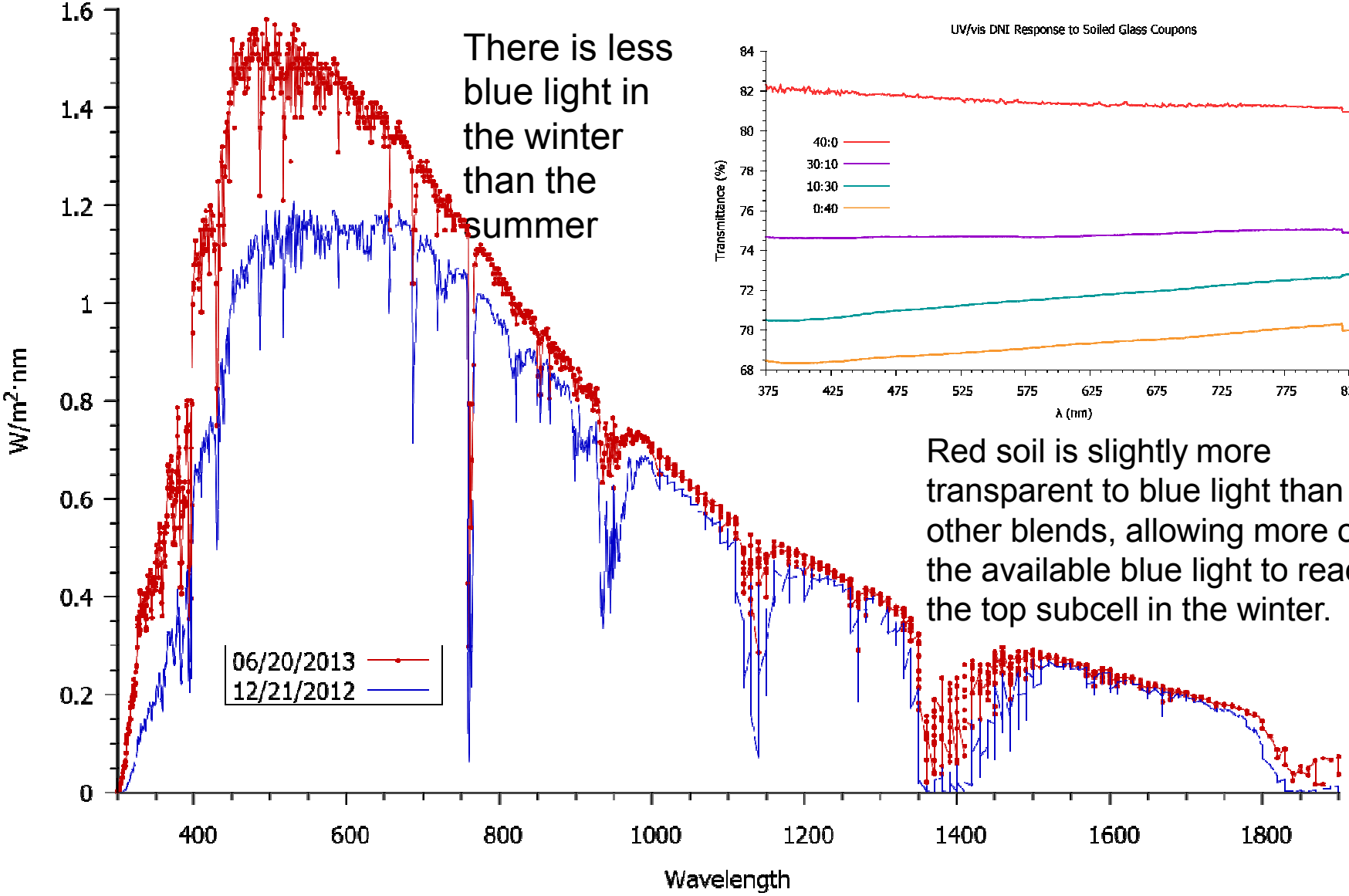


Reference shown in black, mass loadings in decreasing intensity.

The switch from top to middle current limiting condition is consistent for red soil.

Note that the middle junction is always limiting in the winter.

Seasonal availability of light, coupled with soil, can influence device behavior



Red soil is slightly more transparent to blue light than other blends, allowing more of the available blue light to reach the top subcell in the winter.

Summary and Conclusions

- Device response can be modeled using measured optical properties of soils and known quantum efficiency.
- The magnitude of loss predicted for multijunction cells was insensitive to soil type
- Current limiting behavior *was sensitive* to soil type
- Predicted limiting behavior was less consistent for spectrally responsive (yellow) soils
- Seasonal variations were also noted, and may be useful for determining cost-effective cleaning strategies in the winter