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Interactive Comment

Interactive comment on "Solar irradiance at the Earth's surface: long-term behavior observed at the South Pole" *by* J. E. Frederick and A. L. Hodge

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We appreciate the thoughtful comments provided by Anonymous Referee #1. Some of the comments are best addressed in an upcoming revision of the paper. These include an expanded description of the instrumentation and additional references to previous studies. The following paragraphs consider several of the technical issues raised by the referee.

1. Page 25876 on the angular corrections: The referee report outlines a scenario in which an imperfect correction for the cosine response leads to an apparent wavelength dependence in the irradiance ratios. This would effectively contaminate the behavior shown in Figure 6.

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Interactive Discussion

Discussion Paper

When fractional cloud cover is present, the angular distribution of downward diffuse radiance incident on the sensor can vary with polar and azimuthal angle in a complicated manner that can not be modeled rigorously. This creates uncertainties when applying corrections for an imperfect cosine response to the measured irradiances, which may be entirely diffuse or a sum of direct and diffuse components, depending on the sky condition. Given the complexity of addressing this issue from first principles, we take two simpler approaches below.

Approach A: Assume that, in reality, R(UV-A) = R(Visible) and that the measured wavelength dependence in Figure 6 is an artifact of uncorrected errors in the cosine correction. How large must the errors be in order to lead to the relationship R(UV-A) = 0.565 + 0.402xR(Visible) derived from Figure 6?

If R(Visible) = 1.2 (a partly cloudy sky with the solar disk not obscured), then the measured value of R(UV-A) is 12.7% smaller than the correct value (1.0474 versus 1.2). If R(Visible) = 0.6 (solar disk obscured, sky likely 100% cloud covered), then the measured value of R(UV-A) is 31.9% larger than the correct value (0.7912 versus 0.6). The result for the case of R(Visible)=0.6 is especially important since the diffuse irradiance should be nearly isotropic over the hemisphere here, minimizing the uncertainty in the cosine correction. Although the above argument is not definitive, these differences seem unreasonably large to arise entirely from uncorrected cosine errors.

Approach B: How does a result based on a radiative transfer calculation compare to the measurements?

Figure 11 shows that a purely model-based result produces a wavelength dependence that is remarkably close to that deduced from the measurements. This approach provides the most convincing argument that the empirical results in Figure 6 are valid.

2. Figure 10 and the discussion on page 25882 related to irradiances when the solar disk is obscured by clouds: A fractional cloudiness equal to “zero” here refers to the sky being free of clouds except for a small disk that coincides with the area subtended

by the sun as seen from the sensor. So strictly, the fraction cloudiness is not really zero here. The calculation assumes that a fraction of the incident direct irradiance, determined by the cloud albedo, is transmitted through the small cloud and is converted entirely to diffuse radiation in the process. The revised paper will clarify these points.

3. Comparison to recent results in Nature: The paper by Haigh et al. has appeared since we submitted our work to ACP. We will definitely incorporate a comparison into our revised paper. Note that Haigh et al. report variations in wavelength bands that differ from those of the South Polar data, so some care will be needed in doing the comparison.

Our original manuscript had access to the 2009 Geophys. Res. Lett. paper by Harder et al. (doi:10.1029/2008GRL036797) which reported an unexpectedly large solar cycle decline in the UV-A accompanied by a change in the visible of the opposite sign. Our results, however, show a decrease in both the UV-A and visible with the declining phase of the solar cycle. Since our data refer to the ground, there is no way to distinguish changes inherent in the sun from changes in the transmission of the atmosphere. If we claim that all of the long-term variability that we infer is extraterrestrial in origin, then there is a clear disagreement with the wavelength dependence of Harder's results.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 25871, 2010.