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Sky-Radiance Models for Monte Carlo Radiative Transfer Applications

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Photon-tracing can be initialized through sky-radiance (L_{sky}) distribution models when executing Monte Carlo simulations for ocean color studies. To be effective, the L_{sky} model should: 1) properly represent sky-radiance features of interest; 2) require low computing time; and 3) depend on a limited number of input parameters. The present study verifies the satisfiability of these prerequisite by comparing results from different L_{sky} formulations. Specifically, two L_{sky} models were considered as reference cases because of their different approach among solutions presented in the literature. The first model, developed by the Harrisson and Coombes (HC), is based on a parametric expression where the sun geometry is the unique input. The HC model is one of the sky-radiance analytical distribution applied in state-of-art simulations for ocean optics. The coefficients of the HC model were set upon broad-band field measurements and the result is a model that requires a few implementation steps. The second model, implemented by Zibordi and Voss (ZV), is based on physical expressions that accounts for the optical thickness of permanent gases, aerosol, ozone and water vapour at specific wavelengths. Inter-comparisons between *normalized* $\widehat{L}_{\text{sky}}^{\text{ZV}}$ and $\widehat{L}_{\text{sky}}^{\text{HC}}$ (i.e., with unitary scalar irradiance) are discussed by means of individual polar maps and percent difference between sky-radiance distributions. Sky-radiance cross-sections are presented as well. Considered cases include different sun zenith values and wavelengths (i.e., $\lambda = 413$, 490 and $665\,\text{nm}$, corresponding to selected center-bands of the MEdium Resolution Imaging Spectrometer MERIS). Results have shown a significant convergence between $\widehat{L}_{\text{sky}}^{\text{HC}}$ and $\widehat{L}_{\text{sky}}^{\text{ZV}}$ at 665nm. Differences between models increase with the sun zenith and mostly with wavelength. For Instance, relative differences up to 50% between $\widehat{L}_{\text{sky}}^{\text{HC}}$ and $\widehat{L}_{\text{sky}}^{\text{ZV}}$ can be observed in the antisolar region for $\lambda = 665\,\text{nm}$ and $\theta^* = 45\,^\circ$. The effects of these differences was afterwards investigated by analyzing how these models vary the sun and sky photon fraction in MC simulations that use the diffuse-to-total irradiance ratio. In this case, differences up to 14% have been found for $\lambda = 665\,\text{nm}$ and $\theta^* = 60\,^\circ$. The study recommendation is then using L_{sky} models that, like the ZV expression, account for the wavelength dependence of light interaction with atmospheric particles and molecule when initializing MC simulations for ocean color applications, mostly in the case of analyses including the blue region of the visible spectra. Dr. Giuseppe Zibordi, Prof. Pedro Vieira and Tamito Kajiyama are duly acknowledged for valuable discussions. This study has been partiallysupported by ESA under contract n. 12595/09/I-OL with FCT/UNL, Portugal.