MEASUREMENT OF SPECTRAL-ANGULAR RADIANCES OF COASTAL WATERS IN THE KOREAN SOUTH SEA

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ABSTRACT:

The radiance observed from the ocean depends on the illumination and viewing geometry along with the water properties, and this variation is called the bidirectional effect which is important to be considered in ocean color remote sensing. In the present study, as a preliminary step, the spectral-angular radiances in coastal water were investigated with experiments for a range of viewing geometric conditions (0-70°). Over a phytoplankton-dominated water surface the upward radiance for visible and near-infrared wavelengths (example, SeaWiFS and GOCI) increased at nadir and decreased toward the near-horizon, becoming dependent of viewing angles (with higher radiance at nadir view angle and lower radiance at near-horizon viewing angle). This variations were better expressed by the Q-factor, which relates upwelling radiance to the upwelling irradiance (i.e., $Q = E_u/L_u$, also dependent on Sun's position). The Q-factor for this case was more non-uniform with the considered wavelengths and was dependent on viewing geometric conditions. These experimental results confirm the previous similar findings in other coastal waters.

KEY WORDS: Bidirectional correction, SeaWiFS, GOCI

1. INTRODUCTION

Recent evidence based on theoretical and modelling work undertaken by Morel and his co-workers, has shown that the upward radiance field just beneath, and just above, the ocean surface is generally anisotropic, which results mainly from nonisotropic characteristics of the water body's volume scattering function, combined with the lighting conditions (determined by the Sun's position and the relative properties of direct and diffuse illumination) that exist above the ocean surface. Although this is considered as an important parameter in ocean color remote sensing, the practical consequences of these findings are not yet fully examined when interpreting the marine signal recorded by a satellite ocean color sensor.
Thus, the present study is prompted, essentially based on measurements, by the implication of this anisotropy phenomenon in the ocean color remote sensing problem, as the radiance emerging from the ocean depends on the bidirectional characteristic of the upward radiance field just beneath the interface. Our primary aim is twofold: (1) to quantify systematically the variations of the spectral upward radiances just beneath and just above the ocean surface (with varying water constituents), when the geometric configuration is changed regarding the zenith observation angle, zenith Sun angle and azimuth difference between the solar and observation vertical planes, and (2) to quantify the bias introduced into the water constituents' concentration retrieval, when the angular variations of upward signal are ignored. This preliminary study, however, is to analyse variations of the upward radiance field and Q-factor in the wavelength domain (generally used for the quantitative detection of water constituents) for changing viewing geometric configurations.

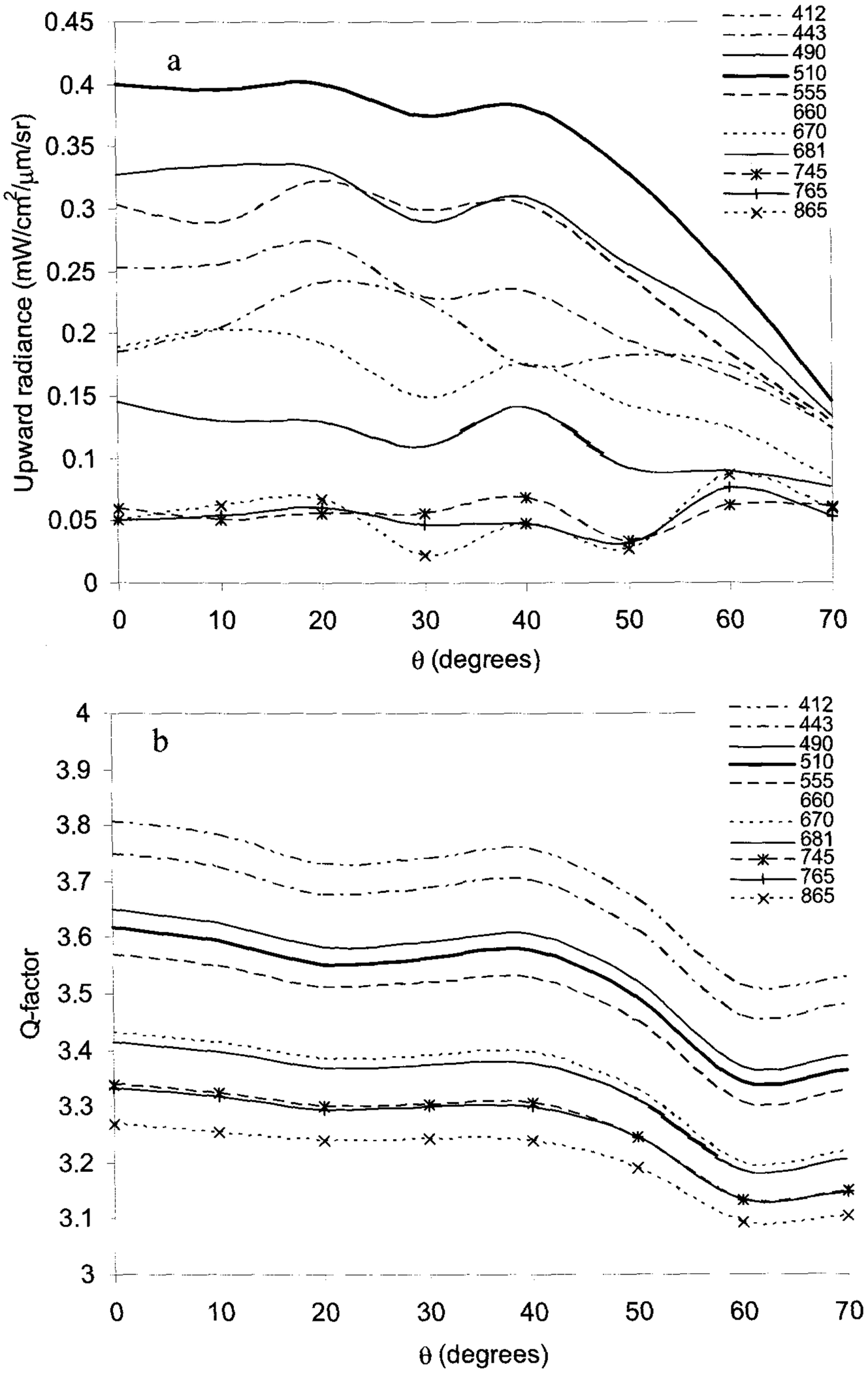
2. METHODS

Measurements of the upward radiance were made in phytoplankton-dominated coastal water in the Korean South Sea (KSS), using an ASD FieldSpec Pro-Dual VNIR Spectroradiometer in the spectral range 350-1050nm with a spectral resolution of 1.4nm. This instrument has separate sensors to detect the upward and downward radiances; here the observation method was changed with a 3D cylinder with a circular base and a vertical symmetry axis measuring 30cm in height and few centimetres in radius. The casing was designed perfectly absorbing (i.e., black) and the sensor was attached at its base so that could be immersed in the upper layer of water to measure the upward angular radiance. Two measurement axes were considered, wherein in the centre of the axes the sensors were located and shifted from the central axis (in four directions) along the sun-plane and a plane perpendicular to the sun-plane. All data collected for this measurement setup were analyzed and only some of the results are presented in this paper.

3. RESULTS

Fig. 1a shows the upward radiances (mW/cm^2/μm/sr) measured along a plane perpendicular to the sun-plane

(only θ=0-70° and away from the ship) at SeaWiFS and GOCI wavelengths (measurements along the same plane θ=-0-70° were not shown here because of possible ship-shadow effect). It appears that the shape of the nadir and near-nadir radiances become quite stable for all wavelengths in the visible and near-infrared domain. However, the general shape of the 30°-70° cases is dependent on the viewing angle (θ), being consistent with previous observations (Morel et al, 1995; Morel and Gentili, 1996). Overall, the angular variation of the measurements data suggests that, as θ increases more area was viewed and thus the upward radiance of the phytoplankton-dominated water decreases at all wavelengths (despite there are some fluctuations at θ=20 and 40 and at some bands). Fig. 1b shows the variation of Q-factor as a function of wavelength and θ along the same plane of observation. It becomes obvious that the Q-factor is much more dependent on the viewing angle, decreasing with increasing θ at all wavelengths of the SeaWiFS and GOCI sensors. These preliminary results suggest the importance of the bidirectional corrections to be made while processing satellite ocean color image data.



Figures 1a and b. The upward radiances (mW/cm²/μm/sr) and Q-factor measured along a plane perpendicular to the sun-plane (only θ=0-70° and away from the ship) at SeaWiFS and GOCI wavelengths.

4. CONCLUSION

We have presented our measurements results of the spectral-angular upward radiances in phytoplankton-dominated coastal water off the KSS coast. The preliminary analyzes suggest that the bidirectional variation (along the sun-plane and a plane perpendicular to the sun-plane) of the upward radiance from nadir direction, as well as the variation of this particular radiance with varying viewing angles are significant. Thus, we conclude that the application of the bidirectional correction is needed for a meaningful comparison of the normalized water-leaving radiances inside and between various scenes, as well as for a merging of data obtained from various sensors under various geometrical configurations. In the future work, we will focus on this problem in various coastal water cases, as well as in various illumination conditions.

References

Morel, A., Voss, K.J. and Gentili, B., 2005. Bidirectional reflectance of oceanic waters: A comparison of modelled and measured upward radiance fields, *Journal of Geophysical Research*, 100, 13143-13150.

Morel, A. and Gentili, B., 1996. Diffuse reflectance of oceanic waters. III. Implication of bidirectionality for the remote sensing problem, *Applied Optics*, 35, 4850-4862.