Radiometric Calibration of a Coastal Ocean Hyperspectral Imager Using a Blue Enhanced Integrating Sphere

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Abstract. The United States Naval Research Laboratory has been conducting hyperspectral remote sensing of the coastal ocean environment for nearly a decade and has recently extended the area under study into riverine estuaries. Data products include bathymetry, bottom and water classification, suspended sediments, CDOM, and phytoplankton. Surveys using the Portable Hyperspectral Imager for Low Light Spectroscopy (PHILLS) (Davis, et. al) have been performed at various locations including the Chesapeake Bay watershed region, Florida's east coast and Indian River areas, the Monterey coast, and the New Jersey coast at LEO XV.

Until now, radiometric calibrations have been performed using a Labsphere Unisource 4000, a 91cm integrating sphere with a 35.5cm exit port. It is illuminated by one to ten quartz halogen lamps internal to the sphere. The lamps are operated with a peak wavelength of about 1 micron or equivalently a black body temperature of about 3000K. Unfortunately the spectral shape of the lamps is not a good match to the spectral radiance measured in the field, as shown in figure 1. The net result is that the calibration of field data must be based on an extrapolation of a linear calibration curve since most of the spectral radiance levels from the sphere lie outside of the range of typical field radiances. This is shown in figure 1 for two measured field radiances. The first is of a cloud top and the other is for typical open ocean signal. The sensor is constructed so that it approaches full well capacity (yet not in the nonlinear region) when viewing clouds, and detects at the mid to lower end of the sensor's gain curve for water leaving radiances. As can be seen, at shorter wavelengths, the field radiances are larger than the sphere output at three lamps, and at the longer wavelengths the field radiances are smaller than the sphere output at just one lamp. Since calibrating the field data must rely on this extrapolation, small nonlinearities along the gain curve are hidden and can produce artifacts. One could argue that you could use lower intensity lamps, however this would only allow for a larger number of matched field/sphere radiances at longer wavelengths, but still no matches at the shorter wavelengths. Note that for most field modes (set by integration time, aperture, and lens), the sensor will saturate at longer wavelengths at three lamps. Since the sensor's CCD is read out in the spectral dimension, blooming creates unwanted signals at the shorter wavelengths. This sets an upper limit to the intensity of the lamps.

To combat these issues NRL, in conjunction with Labsphere, developed a "blue-enhanced" sphere using an external Xe arc lamp from Oriel in addition to an external halogen lamp. The sphere measures about 52cm in diameter and has a 23cm exit port. The resulting spectral output of the sphere is shown in figure 1, where it can be seen to more closely resemble typical field radiances over the full wavelength range of the instrument ,than does the Unisource 4000. During calibration, at-sensor radiance is controlled using apertures at the entrance ports of the sphere or by using well characterized, absorptive neutral density filters placed in front of PHILLS. In this paper, comparisons of calibrations using the two separate sources will be presented. Particular attention will be placed on possible calibration artifacts due to the spectral lines produced by the Xe lamp.

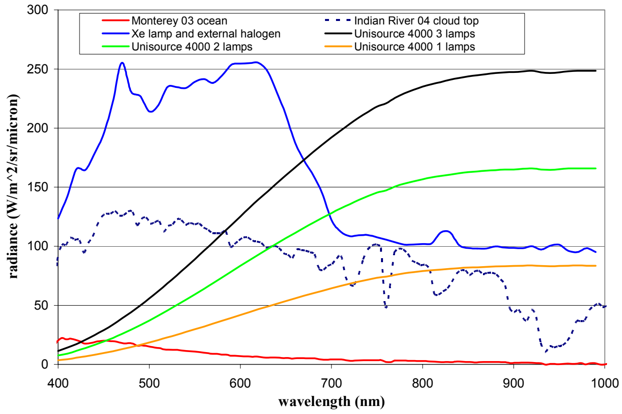

Figure 1. Comparison of the radiances of the Unisource 4000, the Blue-enhanced sphere, and typical field measurements (cloud top and open ocean)

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References

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