Abstract
TOA (top-of-atmosphere) radiance from high-spatial-resolution satellite imagery systems is important for a wide variety of research and applications. Many research initiatives require data with absolute radiometric accuracy better than a few percent. The conversion of satellite digital numbers to radiance depends on accurate radiometric calibration. A common method for determining and validating radiometric calibrations is to rely upon vicarious calibration approaches. Historically, vicarious calibration methods use radiative transfer codes with ground-based measurements of atmosphere and surface reflectance or radiance as inputs for estimating TOA radiance values. These TOA radiance values are compared against the satellite digital numbers to determine the radiometric calibration. However, the radiative transfer codes used depend on many assumptions about the aerosol properties and the atmospheric point spread function. A measurement-based atmospheric radiance estimation approach for high-spatial-resolution, multispectral, visible/near-infrared sensors is presented that eliminates the use of radiative transfer codes and many of their underlying assumptions. A comparison between the traditional radiative transfer and simplified measurement-based approaches is made.

Simplified Radiometric Calibration Approach
- The simplified radiometric calibration approach makes use of the spherical albedo formulation to describe the relationship between surface reflectance and TOA radiance.
- From the spherical albedo, it can be seen that the sensor-measured TOA radiance of a zero-reflectance target is equal to the contribution to TOA radiance that results only from the atmosphere and the background.
- As the target reflectance approaches zero, the TOA radiance approaches the atmospheric and background radiance and can be expressed in terms of a sensor calibration coefficient and a DN (digital number).
- A method for finding the zero-reflectance DN is the ELM (Empirical Line Method), which uses the measured reflectance for several targets to develop a relationship between DN and reflectance for a given remotely sensed image.

Traditional Vicarious Calibration
- Traditional vicarious calibration of spaceborne sensors relies on the collection of ground truth data coincident with a sensor overpass for use with a radiative transfer code.
- At Stennis Space Center, TOA radiance is generated using the radiative transfer code MODTRAN (Molecules, Oceans, Radiative Transfer).
- Successful execution of these codes requires knowledge of the atmosphere, including atmospheric transmission, vertical column profiles of water vapor, pressure, and temperature, total column ozone, and aerosol asymmetry and size distribution.
- Assumptions must be made about several atmospheric parameters, including the atmospheric point spread function (which controls background contribution to TOA radiance) and vertical column trace gases.
- Collection and processing of data to develop knowledge of the atmosphere can be labor-intensive and complex, necessitating additional verification steps to ensure accurate vicarious radiometric calibrations.

Conclusions
- The simplified radiometric calibration approach produces calibration coefficients for the Quickbird sensor very similar to those produced by the traditional method.
- The simplified radiometric calibration approach coefficients produced were within the standard deviation of the traditional method calibration coefficients.
- The simplified calibration approach has several advantages over traditional methods.
- No assumptions about atmospheric point spread function, aerosols and molecular absorption necessary.
- Reduction in amount and type of ground data collected and processed.
- Currently, the simplified radiometric calibration approach relies on several aspects of ground truth data collection performed by NASA at Stennis Space Center.
- Deployment of multiple large targets spanning a portion of the dynamic range of the sensor.
- Laboratory or field measurements of target BRDF.
- Future implementation of the simplified approach will not require laboratory tarp BRDF measurements because radiance measurements will be made at the sensor viewing geometry.

References