Use of the Lake Frome Ground Truth Campaign as a Cross-Calibration of the Hyperion Instrument

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***Abstract* – The Hyperion imaging spectrometer instrument was launched on the EO-1 spacecraft on November 24, 2000 into an orbit trailing Landsat 7 by one minute. Hyperion has a 7.5 km swath width, a 30 meter ground resolution and 10 nm spectral resolution. The first portion of the mission was used to measure and characterize the on-orbit radiometric, spectral, image quality and geometric performance of the instrument. Ground images were specifically collected for this characterization. This paper discusses the incorporation of a vicarious calibration site, Lake Frome in Australia, into the performance verification of the instrument. Coordination with CSIRO during a ground truth campaign resulted in image data collection on Hyperion over flights on December 20, 2000 and January 5 and 21, 2001 and provided an opportunity to compare predicted top of the atmosphere radiance from various sites at the time of the overpass for cross-calibration.**

I. INTRODUCTION

Vicarious calibration provides a unique opportunity to investigate the characteristics of the instrument from a direction that is user oriented. The process involves extensive ground truth and coordination with spacecraft mission operations to coordinate the time of data collection of the spacecraft with the ground truth measurements. The result is a direct comparison of the top of atmosphere (TOA) measurements made by the instrument with the top of atmosphere predication based on the independently measured ground spectral reflectance measurements and propagation through a predicted atmosphere.

The absolute radiometric calibration of the responsivity of the Hyperion instrument performed on the ground prior to launch is described by Jarecke [1]. The on-orbit calibration was verified by measurements of an internal calibration source and of the solar irradiance and are described in another paper in the Hyperspectral Applications Session (C27BTU paper NO. 1777) in this conference. In this comparison, the Hyperion agreement with the absolute solar spectral irradiance was ± 3 % in the VNIR and Hyperion was 5 to 8 % below the solar model in the SWIR.

A ground truth campaign was carried out by CSIRO between December 17 and 20, 2000 at Lake Frome in coordination with the Hyperion mission. Hyperion images were collected on December 20, 2000 and January 5 and 21, 2001. The January 5th collect was the primary collect used in the study. Lake Frome is an ideal site as the Hyperion ground track aligns with a well established and persistent salt track. Landsat 7 and Advance Landsat Imager (ALI) data collection also occurred.

Top of the atmosphere radiances from the Lake Frome sites at the time of the overpass were estimated by the CSIRO team for January 5th. Further discussion of the Lake Frome site, the accuracy of geo-locating the instrument image with the physical site where the measurements were made and the uniformity of the site over a region comparable to the ground sample distance of the instrument during the campaign is provided in another paper in this conference by Campbell (Special Session 40, SS40MO, paper 1675).

This paper briefly reviews the ground truth campaign and presents preliminary results of the on-orbit agreement in the predicted and measured top of the atmosphere radiances with reference to a cross-comparison with the solar calibration results.

II. LAKE FROME GROUND TRUTH DATA COLLECTION

Lake Frome is located in the north east of South Australia and is a large, normally dry salt lake (playa). The center of the playa is approximately at Latitude: 30^{o}51'S and Longitude: 139^{o}45'E. Fig. 1 is an image of the Hyperion pass over the Lake Frome area showing the field sites. Notice that the sites fall on a path along the center region of the Hyperion swath. The data collected as part of the Lake Frome vicarious calibration effort include spectral, navigation, and atmospheric data.

A. Reflectance Measurements

Spectral reflectance measurements were made with an ASD Field Spec imaging spectrometer for a range of ground sites. The measurements were made over specified ground blocks to account for spatial variation and the mean signatures were established. The measurements were referenced to a standard Spectralon panel. A subset of the sites that were measured is listed in Table 1. These sites were used for the comparison

with Hyperion measurements. Spectral reflectance curves obtained at the sites are presented in the paper cited above.

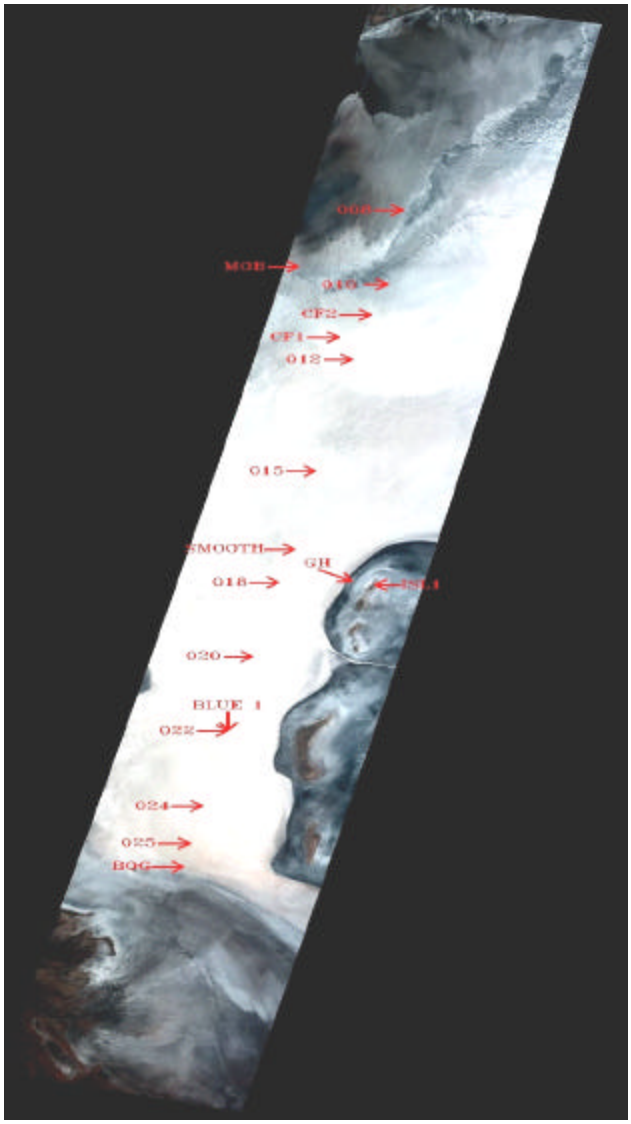

Fig. 1 Lake Frome image taken by Hyperion on the January 5, 2001 overpass.

B. *Navigation Measurements*

Using predicted flight lines of the spacecraft, approximate site locations were chosen. A set of ground control points were selected that could be geo-rectified in Landsat 7 and Hyperion data and GPS measurements were used for accurate site location. A four way match up between January 5th and 12th Landsat 7 and Hyperion images was made with near half pixel predictive errors.

TABLE 1
SITES CHARACTERIZED FOR COMPARISON WITH HYPERION

Name	Date	Latitude	Longitude
018	Uniform Salt	-30.80	139.68
020	Uniform Salt	-30.83	139.67
022	Mixed Salt and Mottle	-30.87	139.66
024	Uniform Salt	-30.90	139.65

C. *Atmospheric Models*

Two sources of measured atmospheric data were available. One was CIMEL data taken at Tinga Tingana (a site established in 1998 in central Australia to study aerosols) that was used to provide estimates of aerosol optical depths and water vapor. The Woomera meteorological station is about equal distance from Tinga Tingana and provides daily radiosondes. These were used to obtain lapse rates for the pressure, temperature and water vapor profiles. These measurements were combined with historical atmospheric knowledge of the region. A basic radiative transfer model was used for the initial investigation.

III. TOP OF THE ATMOSPHERE RADIANCE COMPARISON

Site 20 shows the best overall agreement between the TOA radiances calculated from ground truth and the Hyperion measurements. Fig. 2 presents the spectral radiance curves. The agreement is quite good in the visible and near IR as shown in the expanded wavelength scale in Fig. 3. The mean difference is less than 1.5 % ± 0.5 % from 450 to 900 nm. The CSIRO TOA radiances are 16 % higher than that measured by Hyperion in the SWIR for site 020.

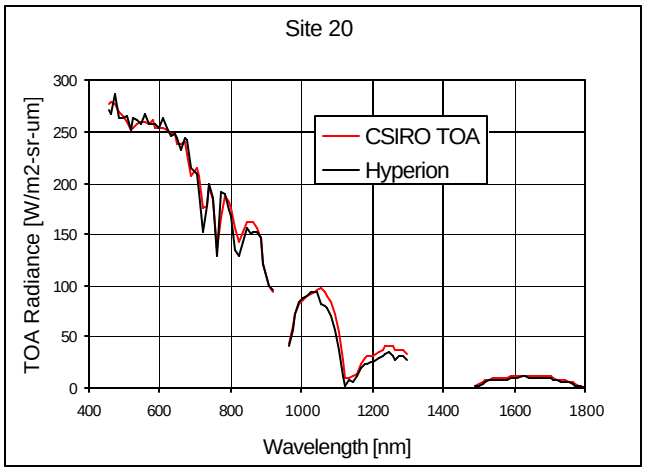

Fig.2. Spectral radiance comparisons over the VNIR and SWIR spectral response region of Hyperion

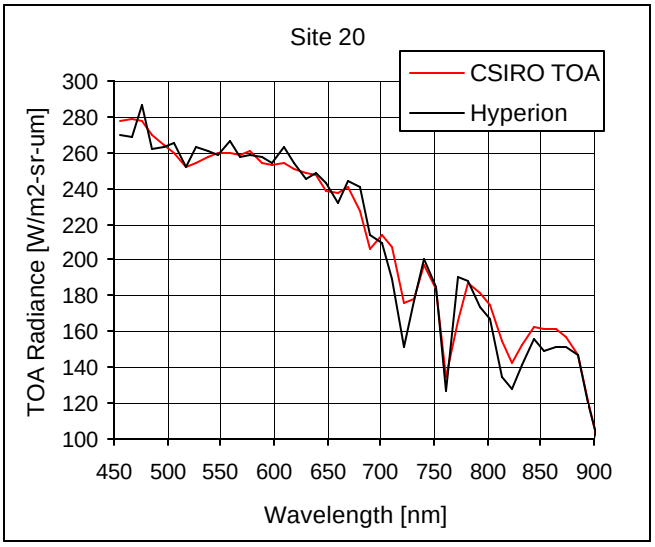

Fig 3. VNIR spectral radiance comparison from Fig. 2

Fig.4 shows the agreement in the VNIR for all four sites. The large swings at 715, 760 and 810 nm may be related to atmospheric correction effects at the spectral features shown in Fig. 3. Otherwise, the general difference ratio ranges from 2 to 10 % throughout the spectral region. In the SWIR, sites 018, 020, and 024 indicate that the TOA model predictions

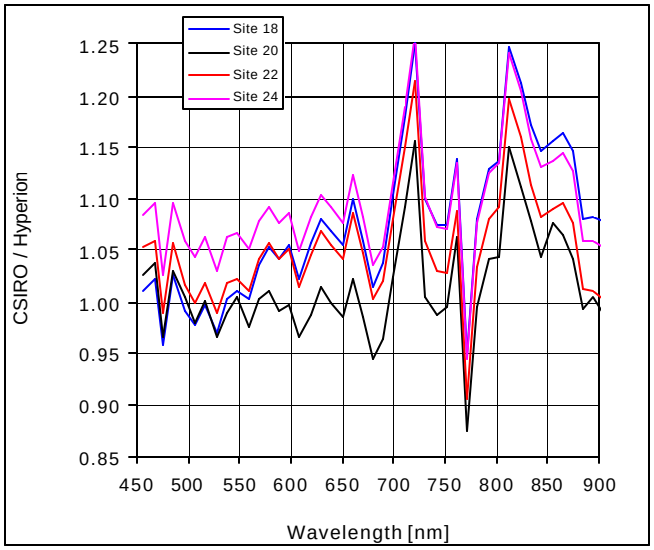

Fig. 4. Comparison for all four sites in the VNIR of the ratio between the CSIRO determined TOA and the Hyperion measurements.

are generally 10 to 25 % higher while site 022 data are lower as shown in Fig. 5. The gaps are where the data are corrupted by the water absorption bands. Corrections for bi-directional reflectance distribution function (BRDF) effects on view angle and the Standard Spectralon panel SWIR performance will improve the validity of these SWIR comparisons.

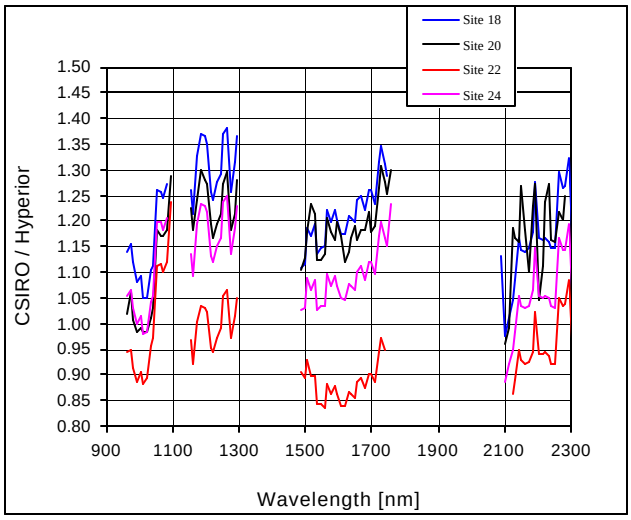

Fig. 5. Comparison for all four sites in the SWIR of the ratio between the CSIRO determined TOA and the Hyperion measurements.

IV. CONCLUSIONS

A vicarious calibration effort at Lake Frome in Australia was incorporated into the performance verification of the Hyperion imaging spectrometer instrument. The ground reflectance measurements and atmospheric correction leading to TOA radiances are consistent with the Hyperion ground and solar calibration at the 5 % to 8 % level in the 450 to 850 nm spectral range. The SWIR agreement is 10 % to 15 %.

REFERENCES

[1] P. Jarecke, K. Yokoyama, "Radiometric Calibration of the Hyperion Imaging Spectrometer Instrument From Primary Standards to End-to-End Calibration ", *Proc. of SPIE*, Vol. 4135 , pp.254-263, August 2000.

[2] S. Campbell, J. Lovell, D.L.B.Jupp, R.D. Graetz, P. Barry, P.Jarecke, J.Pearlman (2001). "The Lake Frome Field Campaign in Support of Hyperion Instrument Calibration and Validation", *IGARSS Special Session 40*. SS40MO. Paper 1675.