AHSI: the Hyperspectral Imager on China's GaoFen-5 Satellite

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Yin-Nian Liu*, De-Xin Sun, Xiao-Ning Hu, Shu-Feng Liu, Kai-Qin Cao

Key Laboratory of Infrared System Detection and Imaging Technologies, Shanghai Institute of Technical Physics, Chinese Academy of Sciences, Shanghai 200083, China

*ynliu@mail.sitp.ac.cn

Abstract. The Advanced Hyperspectral Imager (AHSI) is a visible/short-wave infrared hyperspectral imager on China's GaoFen-5 satellite, which was launched on May 9th, 2018. The AHSI is the first spaceborne hyperspectral sensor that utilizes both the convex grating spectrophotometry and an improved three concentric-mirror (Offner) configuration. It has 60 km swath width, 30 m spatial resolution, 5-10 nm spectral resolution, and 330 spectral bands. Instrument performance was evaluated and validated through well-designed experiments on orbit. Results show that the performance of AHSI has met or exceeded predictions. The AHSI has outstanding capability of detecting and identifying different ground objects and in ecological environment monitoring and natural resource exploration.

1. Introduction

Hyperspectral imaging technology is an important remote sensing technique for target detection, environment monitoring, land resources exploration, disaster monitoring, precision agriculture, forestry survey, and urban planning. A visible and short-wave infrared hyperspectral imager, i.e. the Advanced Hyperspectral Imager (AHSI) was designed and developed by Shanghai Institute of Technical Physics, Chinese Academy of Sciences. The AHSI instrument mounted on the China's GaoFen-5 satellite was launched on May 9th, 2018. AHSI has a spectral range of 400-2500 nm, with spectral resolutions of 5 nm in VNIR (visible/near-infrared), and 10 nm in SWIR (short-wave infrared), respectively. The swath width is 60 km, the total number of spectral bands is 330, and the spatial resolution is 30 m. The performance metrics of AHSI are comparable or superior comparing to the state-of-art advanced hyperspectral sensors, such as recently launched DESIS [1] of DLR-Teledyne (launched in 2018.8), HySIS [2] of India (launched in 2018.11), PRISMA [3] of Italy (launched in 2019.3), and EnMAP [4] of Germany and HISUI of Japan [5] which are scheduled for launch in the next few years.

This paper provides an overview of the AHSI instrument, summarizes the on-orbit performance verification and validation activities.

2. AHSI instrument overview

Figure 1 shows the internal structure and imaging schematic of AHSI. Ground object lights are reflected into an off-axis three-mirror telescope by pointing mirror. The lights are focused on separator of field of view and then split into two parts. One part enters VNIR spectrometer, the other gets into SWIR spectrometer. Compound light is dispersed into a series of monochromatic light by convex grating and

focused on detector by mirror with an improved Offner structure. VNIR detector is back-illuminated frame transfer CCD with a size of 2048×300 pixels. SWIR detector is HgCdTe focal plane cooled at 110 K, and it has a size of 2048×512 pixels that formed by four infrared focal plane arrays (IRFPA) of the same size (512×512) with a staggering spatial arrangement. When calibrating, sunlight is reflected into optical system by diffuse reflectance panel. Absolute radiation response of AHSI is calibrated by solar diffuse reflection signal, and the degradation of the diffuse reflectance panel is corrected by ratioing radiometer. The central wavelength and band-width are calibrated by on-board LED calibration component and the solar atmospheric absorption profile (O_2 adsorption peak @760 nm and 1260 nm).

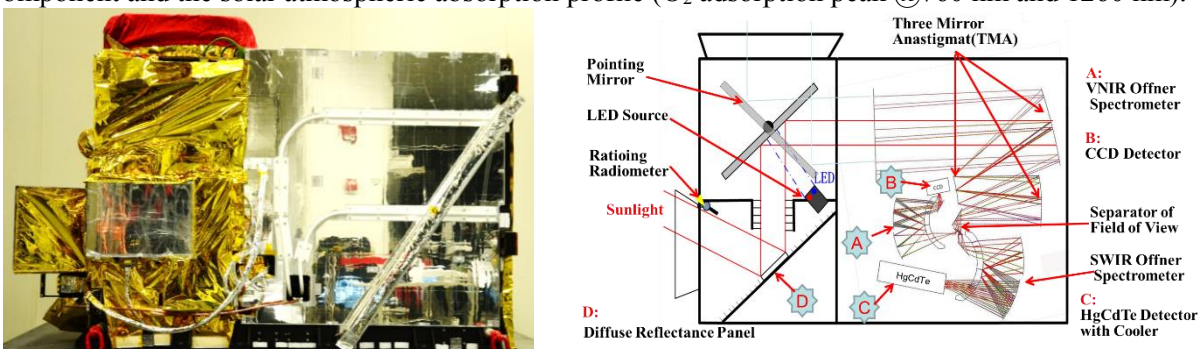

Figure 1. Internal structure (a) and imaging schematic (b) of AHSI on Chinese GaoFen-5 satellite.

3. AHSI on orbit performance

Following launch, the on-orbit characterization of AHSI lasted for 7 months with continuing assessment of the instrument throughout the first year of operations. Table 1 presents the results, the broad spectral range and swath width, high spectral and spatial resolutions, high calibration accuracy of AHSI will meet the challenging requirements of various applications.

Table 1. Summary of on-orbit performance characteristics of AHSI

Characteristic	On orbit calibration
Spectral Range /*μm*	0.39~2.513
Spectral Resolution /*nm*	4.31 (VNIR); 7.96 (SWIR)
Ground Sampling Distance /*m*	29.76~29.95
Swath Width /*km*	59.75
Accuracy of Absolute Radiation Calibration	<2.59% (VNIR); <2.68% (SWIR)
Accuracy of Relative Radiation Calibration	0.35% (VNIR); 0.43% (SWIR)
Accuracy of Spectral Calibration /*nm*	0.32 (VNIR); 0.55 (SWIR)
X-track spectral error /*nm*	0.23 (VNIR); 0.20 (SWIR)
MTF	~0.3
SNR	686 (600nm); 369 (900nm) 452 (1200nm); 460 (1500nm) 405 (1700nm); 194 (2400nm)

References

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