

A high-dispersion echelle spectrograph for radial velocimetry with the 3.8m Seimei Telescope

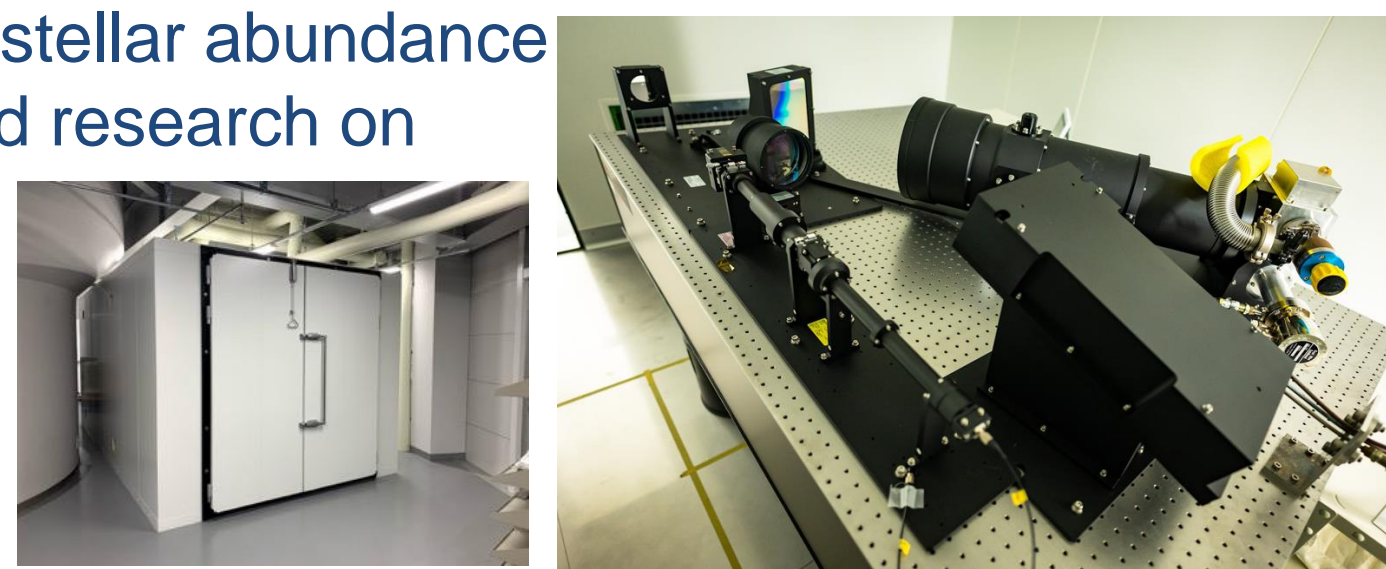
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System Overview

GAOES-RV¹ (Gunma Astronomical Observatory Echelle Spectrograph for Radial Velocimetry) is a high-dispersion echelle spectrograph for the 3.8 m Seimei Telescope at Okayama Observatory, Kyoto University. GAOES², the predecessor of GAOES-RV, had been operated with 1.5-m telescope at Gunma Astronomical Observatory until 2020, and it was refashioned and moved to the Seimei Telescope as a precision RV instrument, GAOES-RV. GAOES-RV has been in operation since July 2023, and is widely used for a variety of scientific observations, including the detection and characterization of exoplanets, stellar abundance analysis, and research on active stars.

Dome 2F Spectrograph



Specifications

Spectrograph	Wavelength coverage	516 – 593 nm (fixed)
	Spectral resolution	R~65,000
	Echelle grating	R = 2.8, 31.6 gr/mm blaze angle 71 deg
	Cross disperser grating	600 gr/mm 554 nm blaze with a 9.5 degree
Fiber	Φ130 μm (= 2.2 arcsec) octagonal core, 35m long	
Image slicer	Bowen-Wolraven type, 5 slices	
Detector	Type	2k x 4k CCD (e2V CCD44-82BI) 15 μm x 15 μm pixel
	Readout system	M-front 2 + Messia-V
	Conversion factor	1.92 & 1.95 e-/ADU
	Readout noise	~4e-
	System dark current	~10 e-/pix/hour
	Saturation level	>51000 ADU
Wavelength calibrators		ThAr, iodine cell
Throughput		~2.5-3.0 %
RV precision		~2m/s for a slowly-rotating bright G-type star

For more details, please refer to our presentation in SPIE 2024.

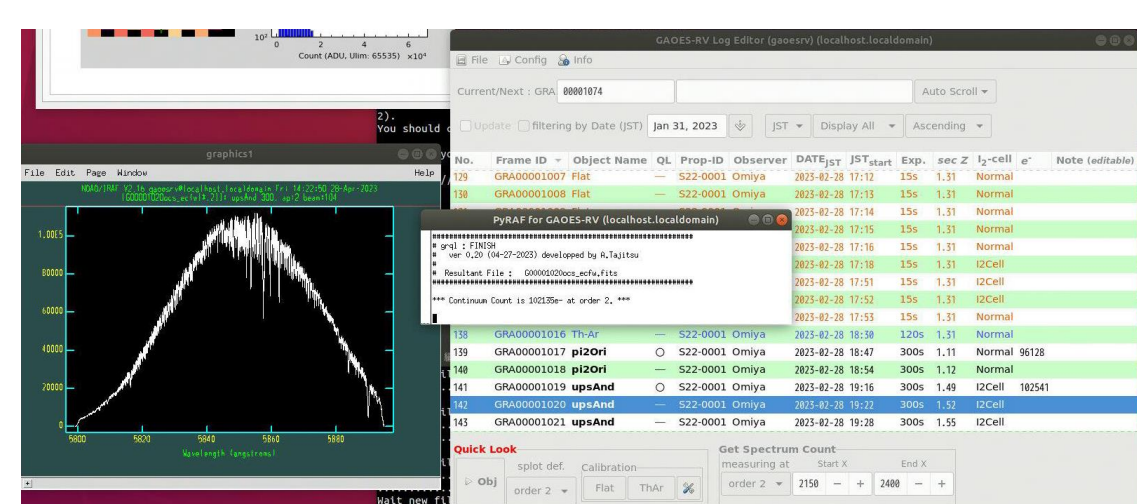
<http://dx.doi.org/10.1117/12.3019538>



Data Reduction / Manuals

Using the auto-logger in the observation environment of GAOES-RV, quick reduction (overscan subtraction, cosmic-ray removal, flat fielding, scattered-light subtraction, wavelength calibration, extraction of 1D spectrum) can be performed within 30 seconds. All related IRAF/PyRAF cI-scripts including the auto-logger software can be downloaded via github. Users can now easily set up the same data analysis environment in their own environments.

Reduced 1D spectrum



Auto-logger

All manuals and software links are compiled on the GAOES-RV web page.



Operation Overview

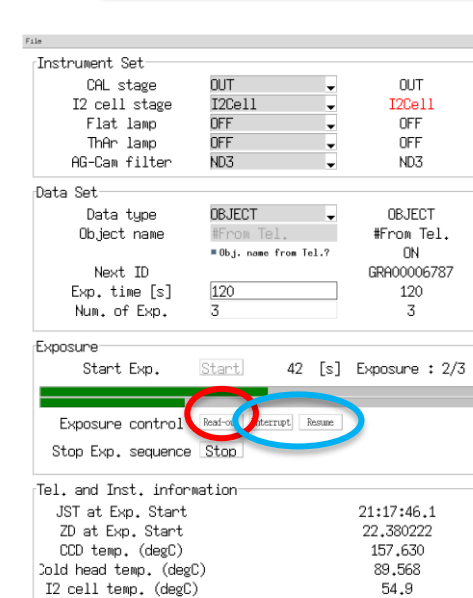
GAOES-RV has been opened for open use of Seimei telescope since the semester 2023B (July), and it has been generally successful in its observations. It has become a popular instrument, used in about half of the projects in Seimei open use, increasing its competition rate from less than x1.5 to nearly x3. The instrument's performance has met expectations almost perfectly, and further scientific outputs are anticipated in the future. To accommodate ToO (Target of Opportunity) observations, the cryostat operates continuously throughout the year, and it has been running smoothly with only minor issues.

GAOES-RV Time Allocation in Seimei Open Use

	# of accepted classical proposals	# of allocated nights
2023B	7/14 (50%)	42.0/57.0 (74%)
2024A	7/16 (44%)	36.5/55.25 (66%)
2024B	6/15 (40%)	28.0/57.25 (49%)

Updates

Midpoint Readout, Interruption/Resume for Exp.



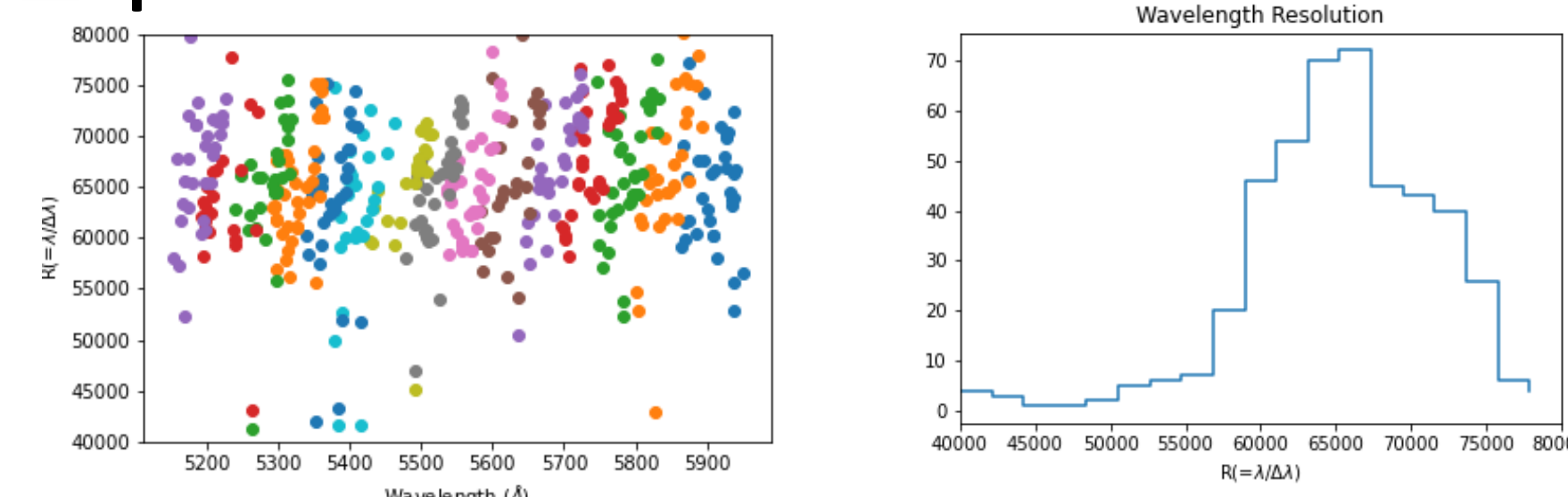
Observers are now able to perform midpoint readouts and interrupt/resume exposures freely during observations, depending on weather conditions and changes in plans.

Maintenance of FITS Headers

Always consulting with the SMOKA team for data archive.

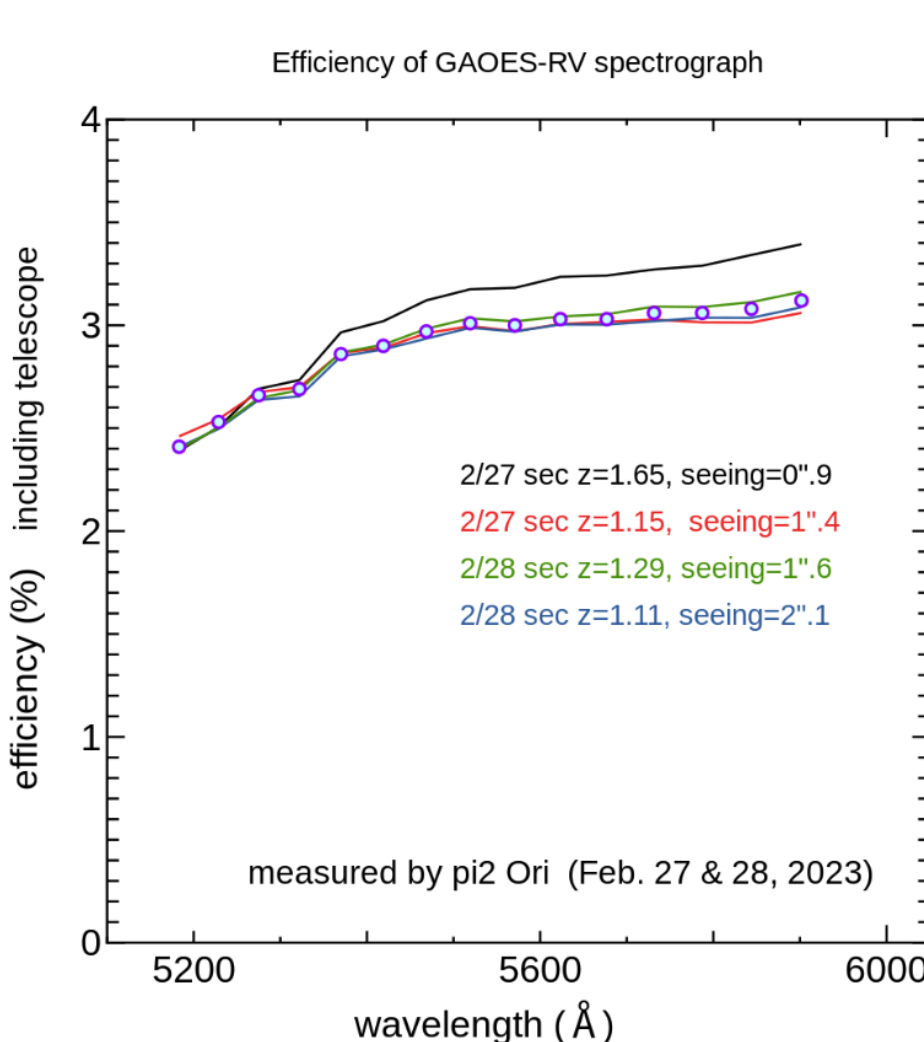
Performance

Spectral Resolution



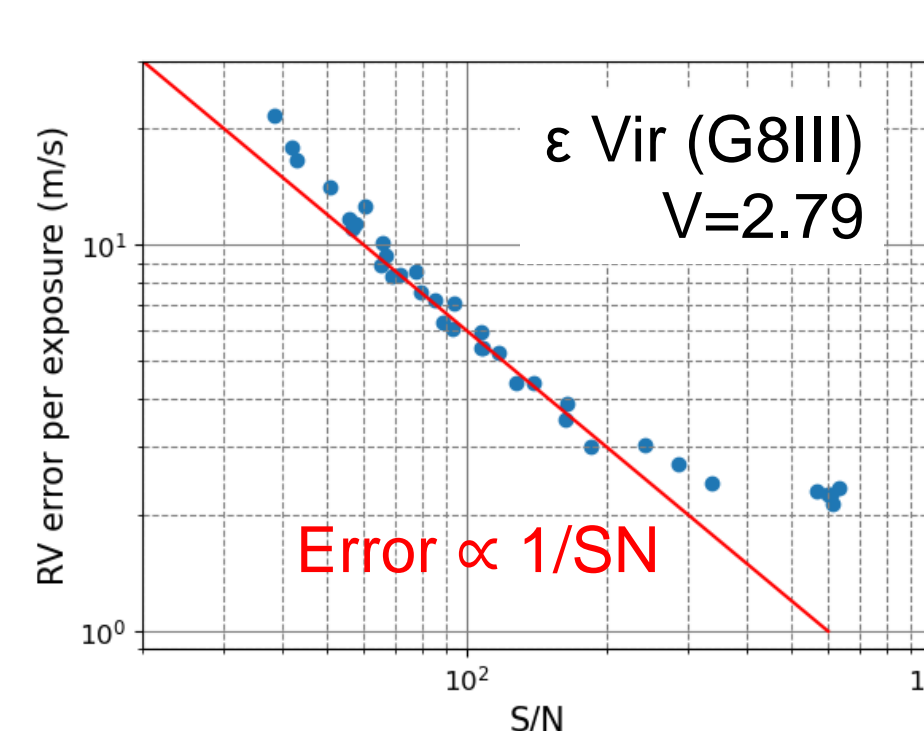
The spectral resolution is R~65000 based on the measurements with the spectrum of the ThAr light source.

Throughput



The efficiency of GAOES-RV with the telescope is 2.5-3% in the observation wavelength range. The actual observation efficiency depends on the atmospheric extinction and the efficiency of the fiber inlet.

Precision RV measurements

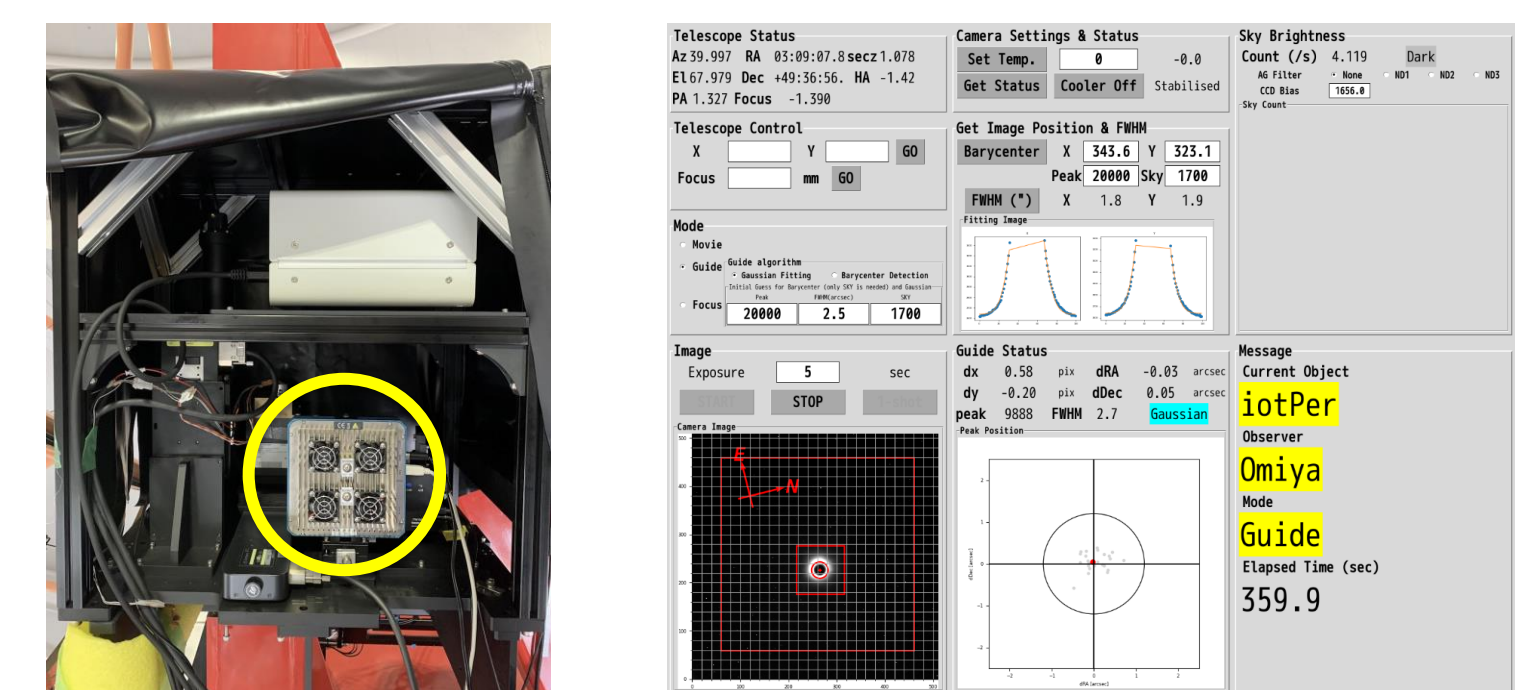


Precision RV measurements are performed with an iodine cell. Currently the precision of about 2m/s per exposure can be achieved for a bright slowly-rotating G-type star. The long-term stability is ~3-4m/s.

Troubles

Guide Camera Trouble (Jul. 2024)

The Apogee CCD camera used as a guide camera broke down and was replaced with the same model from the spare of the 188cm telescope HIDES-F. The schedule was not affected since it was under maintenance at the time. Production of the aircraft has been discontinued, and future measures are currently being discussed.



He Compressor Trouble (Aug. 2024)

Due to high temperatures during this summer, the temperature in the dome exhaust room increased, causing the He compressor (operating temperature range : 4-38°C) to stop. To address the rise in CCD temperature, 0.5 nights of open use were canceled. The exhaust fans and circulators in the exhaust room are currently in use for operation.



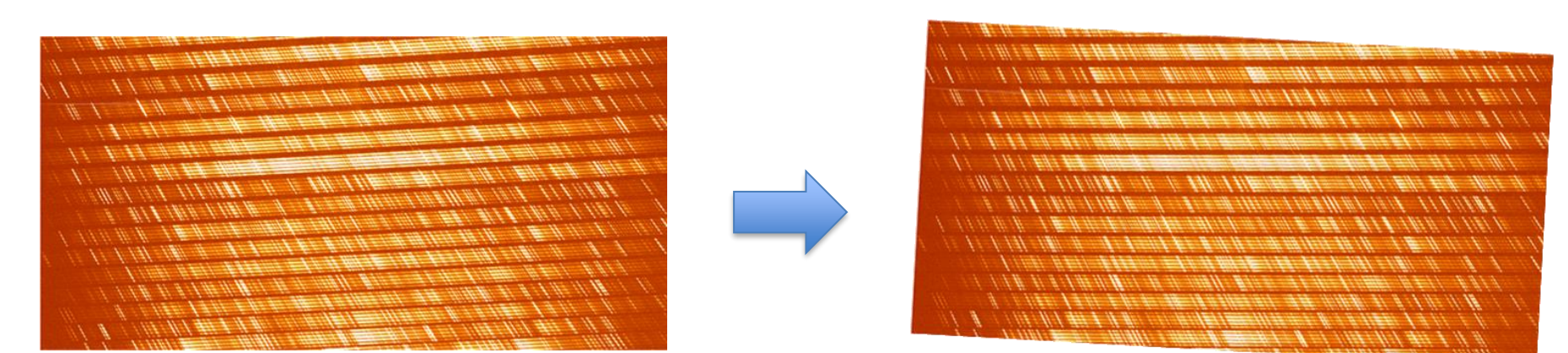
Future Plans

Update the Guide Camera

The urgent need to replace the current CCD, which is no longer manufactured, with a new CMOS camera has arisen.

Detector Rotation

By updating the detector support and rotating the detector by 1.5°, the echelle order and the column direction of the CCD will be aligned. This adjustment will reduce the impact of bad columns.



Support for Automated Observations

Improving software to enable automatic detection of target objects on the guide camera, guiding them to the pinhole, and starting the guiding process.

Enhancing Temperature Sensors and Monitors

We aim to improve the stability of the spectrograph and increase the precision of RV measurements to below m/s.

Backup for the Detector control PC

Currently using the old Messia-V system, but it will be necessary to consider updating to VI in the future.

UPS for PCs

There have been two power outages since August.

Development of "MIDSSAR"

Kyoto univ. is currently developing a pair of medium dispersion spectrograph (MIDSSAR) that splits the light before it enters the GAOES-RV fiber, allowing simultaneous acquisition of medium dispersion spectra of H α and Ca II HK lines in addition to the 500 nm range of the GAOES-RV. The impact on GAOES-RV will be minimal. See MIDSSAR presentations in Day2.