EWS Rapid Revisit Optical Cloud Imager (RROCI) - Early On-Orbit Demonstration Results

Erich E. Hoover[1], Scott Jensen[2] Mark R. Schoeberl[3], Hal Bloom[3]
[1]Orion Space Solutions, [2]ICR, [3]Science and Technology Corporation,

MOTIVATION AND SUMMARY

The U.S. Space Force is evaluating technologies for a new Electro-Optical/Infrared (EO/IR) weather system (EWS) constellation to provide global cloud characterization and theater weather imagery to Department of Defense Weather Centrals.

The **Rapid Revisit Optical Cloud Imager (RROCI)** satellite built by Orion Space Solutions, an Arcfield company, is a CubeSat technology demonstration mission designed to collect such weather imagery in 8 visible and infrared spectral bands. These bands have been carefully tailored and radiometrically calibrated to provide the desired global cloud characterization and theater weather imagery desired by the Space Force at a fraction of the cost of existing systems.

Measurements were validated using NOAA Visible Infrared Imaging Radiometer Suite (VIIRS) on NOAA-20 and the NOAA GOESR Series Advanced Baseline Imager (ABI). Instrument-level radiometric accuracy and noise numbers were found to be consistent with both pre-launch calibration data and model predictions. RROCI used µbolometer detectors which maintained radiometric stability over an estimated 14-hour period. Using supplemental data, we have successfully demonstrated using the µbolometer for radiometry with several days between dark data collections. This data, when compared with VIIRS and ABI, shows that the payload can achieve the EWS weather objectives.

KEY ADVANTAGES

RROCI provides comparable observations to other earth-observing weather instruments, but with several key advantages:

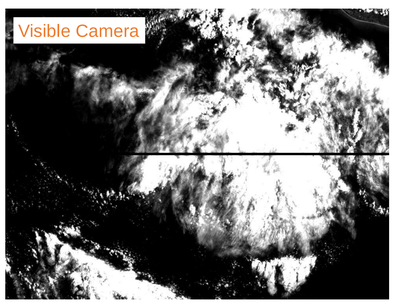
1. **Higher Spatial Resolution:** Compared to ABI, RROCI has higher ground spatial resolution imagery. This feature also contributes to better cloud typing.
2. **Flexibility:** RROCI is designed to support rapid iteration, permitting new wavelengths in the range of 0.4 µm to 14 µm to be added or removed from the system without a full payload redesign.
3. **Rapid Deployment:** The RROCI instrument can be rapidly assembled and calibrated, going from signed contract to delivery to the launch site in 11 months' time.
4. **Multi-domain Applicability:** The RROCI payload architecture is designed to operate to operate in various environments from LEO to MEO without substantive design changes.
5. **Cost:** RROCI uses low-cost commercial off-the-shelf (COTS) cameras, mostly COTS lens assemblies, and relatively low-cost custom filters to achieve a previously inaccessible price-point.

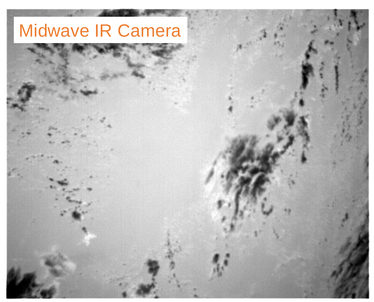
RROCI images collected off the coast of Brazil (June 18, 2024)

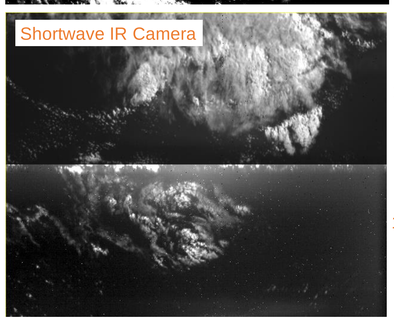
Reference Map

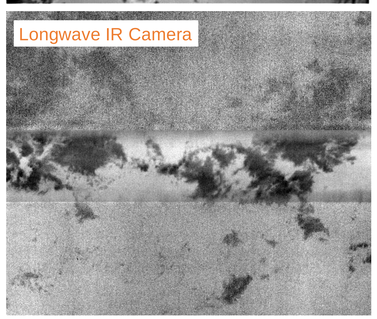


Projected Ground Track



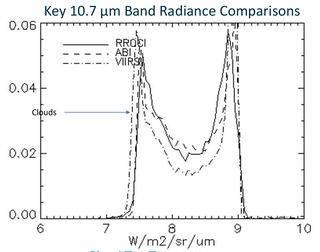


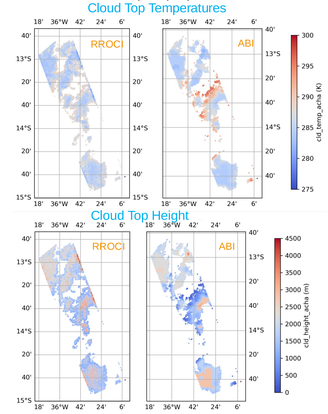




Images shown not collected simultaneously.
Shortwave IR bands scaled independently for better visualization.
Longwave IR rows scaled by row median value for better visualization.

INITIAL ON-ORBIT RESULTS





Radiance Comparisons

- The key workhorse channel (10.7 µm) shows spectral radiance within 1-3% of ABI and VIIRS values.
- The measured on-orbit µbolometer performance demonstrates a successful approach to using low-cost COTS cameras and custom filters for longwave IR measurements
- Our results with the longwave IR camera improved even further with simple noise reduction algorithms that simulate the science-mode Time Delay and Integrate (TDI) collections

Cloud Top Temperature

- The higher resolution RROCI radiance, largely due to LEO versus GEO orbit, is evident when compared to ABI
- Only pixels that were ‘cloudy’ for both fields were compared when estimating the uncertainty (19,023 cloudy points)
- For this analysis, OSS assumed ABI to be truth. In this scenario, the RROCI uncertainty is 2.35 K

Cloud Top Height

- Only pixels that were ‘cloudy’ for both fields were compared when estimating the uncertainty (19,023 cloudy points)
- For this analysis, OSS assumed ABI to be truth. In this scenario, the RROCI uncertainty is 0.7 km
- RROCI meets and exceeds the systems requirement (1 km)

Cloud Typing

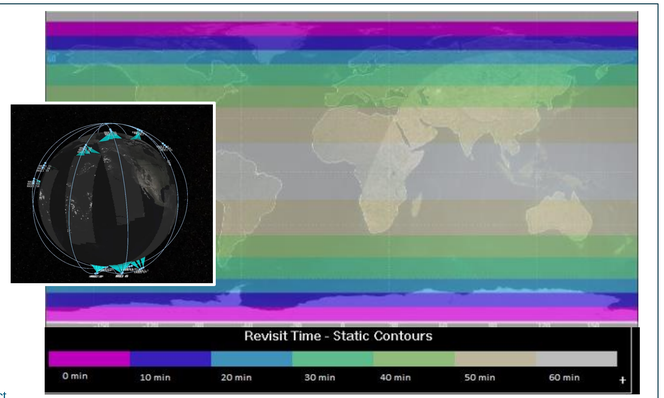
- RROCI cloud typing performs on par with legacy systems, in part due to the higher spatial resolution

After correcting for three-day-old dark offsets, RROCI produced radiometric results within 1-3% of coincident imagery collected by ABI and VIIRS.

NEXT STEPS

- Under an internally funded program, Orion Space Solutions / Arcfield is now developing and planning to launch an upgraded prototype payload that uses higher resolution cameras and captures additional bands for collecting weather, forest fire, and other observing products
- In the future, a constellation of relatively low-cost RROCI sensors could significantly reduce the development and operating cost of producing radiometrically calibrated cloud weather imagery

Acknowledgements: This work was supported by a U.S. Space Force contract (FA8808-23-9-0001).



Notional follow-on constellation

Copyright 2025 Orion Space Solutions, an Arcfield Company