CORONAL IMAGING WITH THE
SOLAR ULTRAVIOLET IMAGER

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Geostationary Operational Environmental Satellite (GOES-R)

Launched: November 19, 2016
Operational: December, 2017

Nadir-pointed instruments:
  Advance Baseline Imager (ABI)
  Geostationary Lightning Mapper (GLM)

Sun-pointed instruments:
  EUVS and X-ray Irradiance Suite (EXIS)
  Solar UltraViolet Imager (SUVI)

Bus-mounted instruments:
  Space Environment In-Situ Suite (SEISS)
  Magnetometer
Solar UltraViolet Imager (SUVI)

- Generalized Cassegrain Telescope
- Multilayer coated primary and secondary mirrors
- Six channels:
  - 9.4nm, 13.1 nm, 17.1nm, 19.5nm, 28.4nm, 30.4nm
- Entrance and analysis filters for bandpass & OOB rejection
- 53 arcmin x 53 arcmin CCD
- Guide Telescope (GT) provides Sun-pointing information
- Spacecraft controls gimbals with the GT data
Motivation

**Observation:**
- SUVI image shows significant corona
  - Largest among solar imagers
- No UV coronagraphs

**Action:**
- Image UV corona up to a few solar radii
- Investigate impacts on spacecraft
- Explore CME detection capability

**Implementation:**
- Develop an operational concept
Caught on camera: X9 flare

2017 September 10*

* Seaton, et al, The Astrophysical Journal Letters, 852:L9 (7pp), 2018 January 1
Off-points

- Distributed symmetrically around the Sun center
- 17.1 nm & 19.5 nm
- Varying exposures
- Accounts for pointing errors
- Traverse and details shown for 17.1nm. (The path is reversed for 19.5nm; details not shown)

- Executed on February 13, 2018
17.1nm Composite

Median +/- RMS radial profile of SUVI 171

GOES-16 Preliminary, Non-Operational Data

4.7*Rsun

Solar Wind 15 Conference
19.5nm Composite

Median +/- RMS radial profile of SUVI 195

GOES-16 Preliminary, Non-Operational Data
Refinements

• 17.1 nm vs 19.5 nm
• Exposure duration reduced w/on-chip binning
• Overlap, accounting for pointing errors, reduced to 2 arcmin
• Other off-points: 3 panels vs. 9, stare at an off-point
• Dynamic disturbances on spacecraft reduced
• Operational concept
  • Patrol mode vs on-demand
  • Use other instrument data as predictive tool
• 3-phase execution on GOES-17
Off-points

Final image size: 155 x 114 arcmin
Advantage: Large imaging area

Final image size: 155 x 53 arcmin
Advantage: Rapid Turnaround

- Covers 4.5x Solar radii in E-W
- 17.1nm and/or 19.5nm
- Fast refresh rate: 4.35 min (single channel)
  - Max observable CME speed: > 6400 Km/s
- ~6 min for two channels
  - 100% of CMEs will be observable

- Overlap in N-S eliminates vignetting
- Covers 3.5x Solar radii in N-S; > 4.5x in E-W
- Refresh rate: 12 min
  - Max observable CME speed: > 3500 Km/s
  - 100% of CMEs will be observable
Phase 1 Execution on GOES-17: Reduced Dynamic Disturbances
17.1nm

20180604_131458

GOES-17 Preliminary, Non-Operational Data

20180605_230203
19.5nm

GOES-17 Preliminary, Non-Operational Data

20180604_131523

20180605_230228
Time lapse movie (freeze frames shown on slides 12 and 13)

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Next Steps

- Run a patrol mode for 1-2 week period
- Process data and correlate with known events from instruments: EXIS, LASCO CCOR2, SDO/AIA, SOHO, etc.
## Conclusion

| Observed Events, 1996-2005 | % of CME Events | Observability in 9 Panel Sequence | Observability in 3 Panel Sequence |
|----------------------------|----------------|----------------------------------|----------------------------------|
| Low Speed CME Events, 200 to 1000 Km/s | 7980 | 96.2% | 100.0% | 100.0% |
| Mid Speed CME Events, > 1000 to 2000 Km/s | 291 | 3.5% | 100.0% | 100.0% |
| High Speed CME Events, > 2000 to 3400 Km/s | 27 | 0.3% | 100.0% | 100.0% |
| All CMEs | 8298 | 100.0% | 100.0% | 100.0% |

**EUV Solar Coronal Imaging – new frontier?**
Backup
Mid Speed and High Speed CME Velocity Events*

- Mid Speed (> 1000 to 2000 km/sec) and High Speed (> 2000 to 3400 km/sec) CME events are infrequent over a 10 year period. Mid Speed CMEs are only 3.5% of all CMEs, while High Speed CMEs are only 0.3% of all CMEs.
- However, Mid Speed and High Speed CME events are often Geoeffective. The combined number of Mid Speed and High Speed CME events (318) is very close to the combined number of Category G3, G4, and G5 Geomagnetic Storm events (304) over an 11 year Solar Cycle.

| Speed CME Events | # of Observed Events, 1996-2005 | % of CME Events |
|------------------|---------------------------------|-----------------|
| Low Speed        | 7980                            | 96.2%           |
| Mid Speed        | 291                             | 3.5%            |
| High Speed       | 27                              | 0.3%            |
| All CMEs         | 8298                            | 100.0%          |

*Naval Research Laboratory*