GOES-17 Post-Launch Testing Summary and Results

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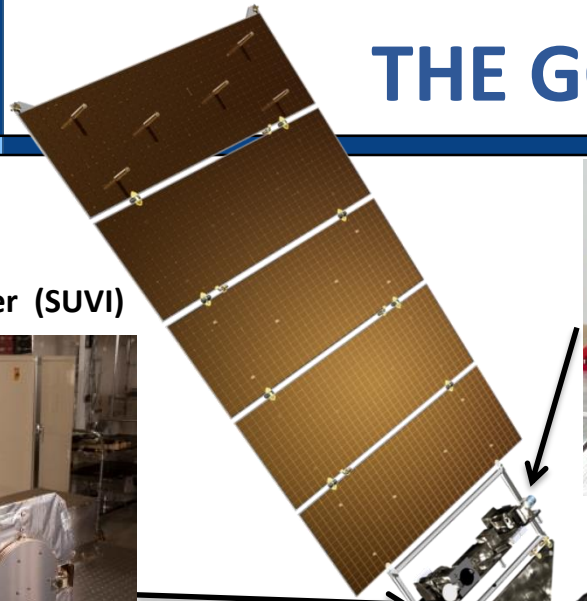
AMS Annual Meeting 2019
15th Annual Symposium on New Generation Operational Environmental Satellite Systems
Session 9A: Calibration and Validation I
Phoenix, AZ

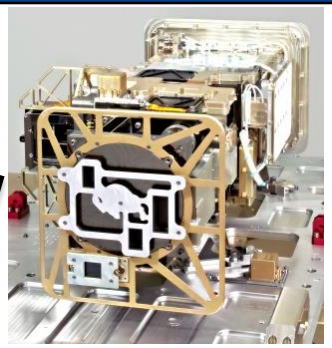
January 10, 2019

Outline

- GOES-R Series Spacecraft Refresher
- GOES-17 Timeline and Milestones
- Post-Launch Test Period
- Data Distribution and Science Product Maturity
- ABI LHP Anomaly Status
- Current Maturity and PLPT Status of L1b Data Products
- GOES-T and U Status

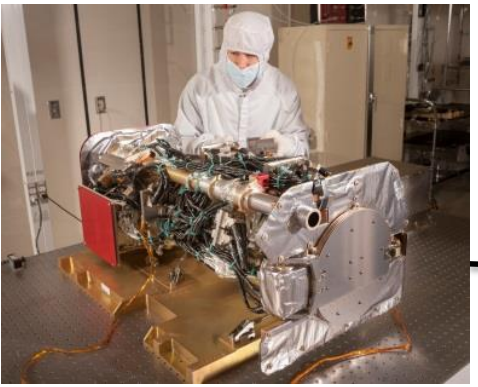
THE GOES-R SERIES SPACECRAFT





Extreme Ultraviolet and X-Ray Irradiance Sensors (EXIS)

Solar Ultraviolet Imager (SUVI)



Space Environment In Situ Suite (SEISS)

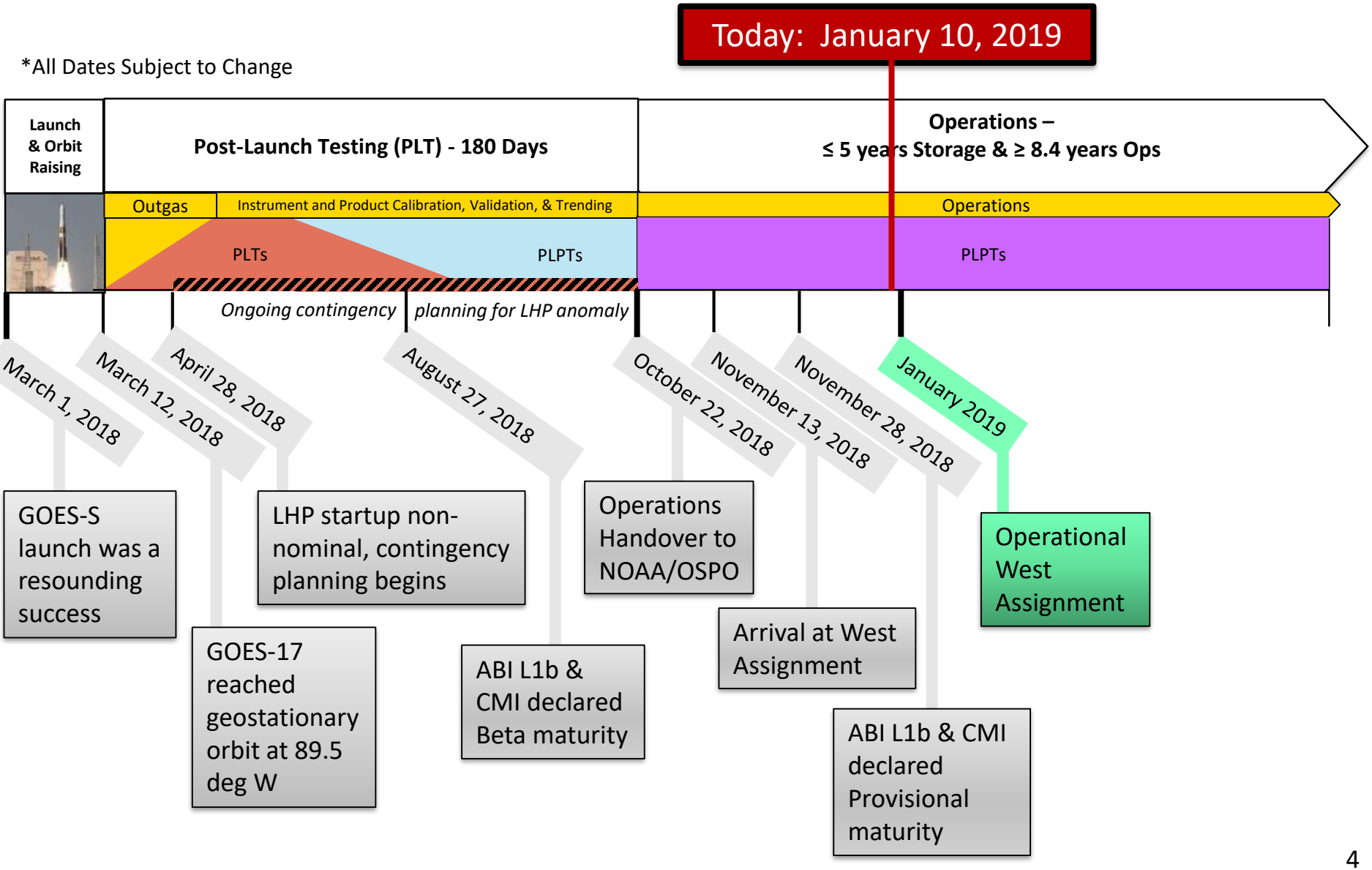
Magnetometer

Geostationary Lightning Mapper (GLM)

Advanced Baseline Imager (ABI)

GOES-S/17 Mission Timeline & Milestones

*All Dates Subject to Change



Post-Launch Testing (PLT) and Product Tests (PLPTs)

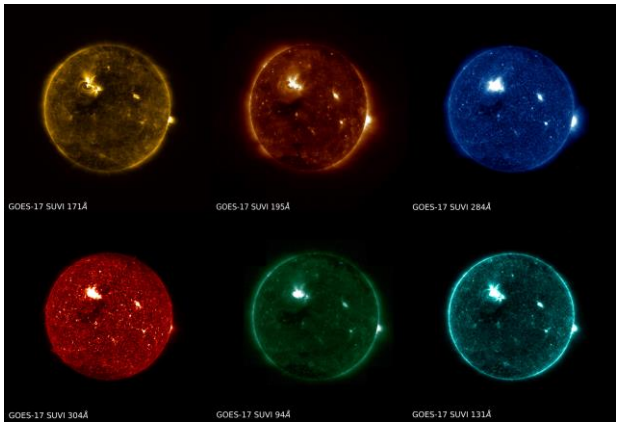
- Post-launch testing is a 6 month testing window that involves all components of the satellite system:
  - Testing is done on the instruments, the guide, navigation and control systems, the communications systems, the ground system, and the spacecraft itself (PLTs)
  - The science products are also given an assessment by NOAA scientists through their own testing and monitoring (PLPTs)

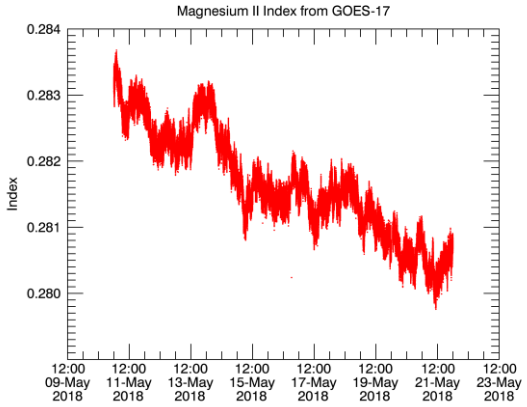
- Lots of procedures and tests are run in non-nominal modes to ensure all aspects are working properly and tuned as fine as possible for the real on-orbit conditions of the satellite

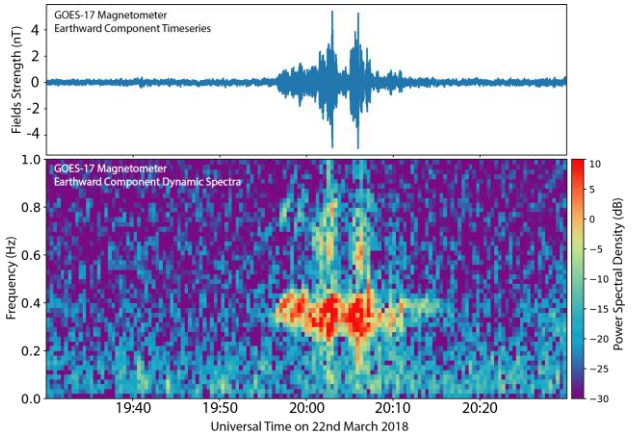
- During PLT, data flows are limited to internal support (MOST), instrument vendors, and cal/val teams

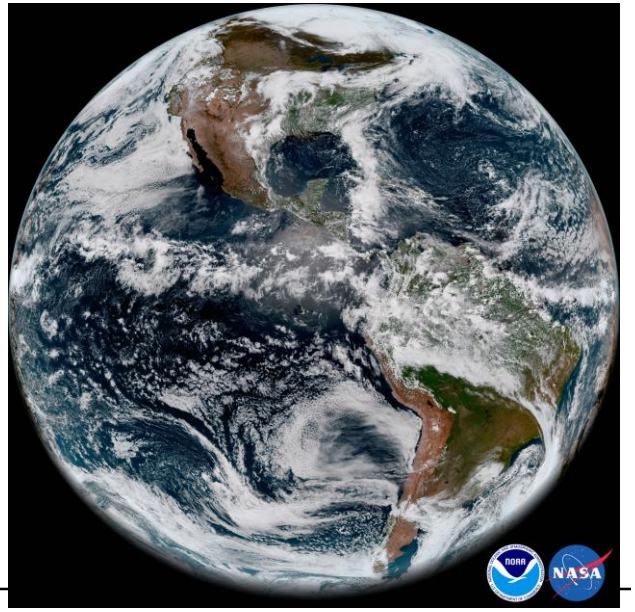
- As the satellite transitions out of PLT and into Operations, most users won't see data until Provisional maturity

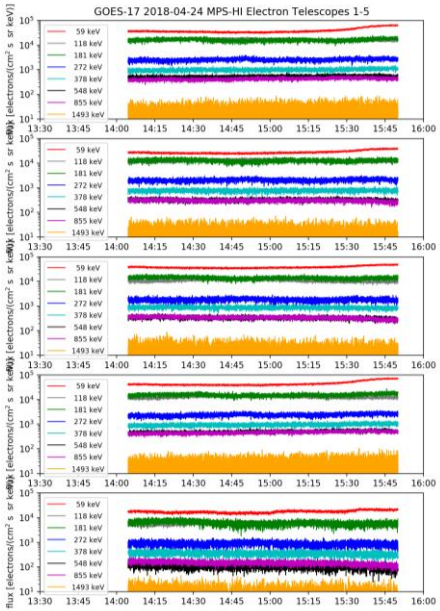
First data from all instruments

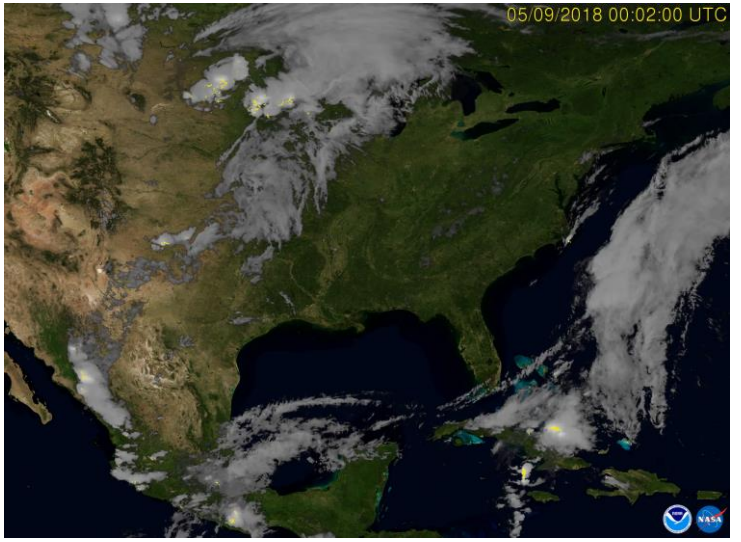












GOES-R Maturity Levels

What do the three Product Maturity Levels mean?

Beta: The product is made available to users to gain familiarity with data formats and parameters. The product has been minimally validated and may still contain significant errors and is not optimized for operational use.

Provisional: Product is ready for operational use but has documented known issues. Product analyses are sufficient to communicate product performance to users relative to expectations.

Full: Product is operational. All known product anomalies are resolved and/or documented and shared with the user community.

G17 Product Generation and Distribution

Instrument	Files being generated	Data Flows Enabled	Date in GRB (2018)	Data Publicly Accessible from CLASS?
SEISS L1b	All sensor L1b files	PDA, CLASS, GRB	August 13	Yes (MPS-HI) Others Jan-Mar
EXIS L1b	XRS and EUVS files		June 28	No
MAG L1b	Geomagnetic field strength files		August 9	No
ABI L1b	Radiances		August 28	Yes
SUVI L1b	Solar EUV imagery		August 22	No
GLM L2	Events, groups, flashes		October 3	Yes
ABI L2+	All product files		N/A	No

All GOES-R Series data are archived in CLASS

When Will G17 Data be Available to the Public?

All (near-term) dates subject to change!

ABI L1b Product	Beta	Provisional	Full
Radiances	8/27/18	11/28/18	11/2019
GLM L2 Product			
Lightning: Events, Groups, Flashes	10/2/18	**12/20/18**	12/2019
SEISS L1b Products			
Energetic Heavy Ions	8/10/18	3/14/19	02/2020
Magnetospheric e^-/p^+: Low Energy	8/10/18	3/27/19	02/2020
Magnetospheric e^-/p^+: High Energy	8/10/18	**12/18/18**	02/2020
Solar & Galactic Protons	8/10/18	1/16/19	02/2020
EXIS L1b Products			
Solar Flux: EUV	6/27/18	2/27/19	02/2020
Solar Flux: X-ray Irradiance	6/27/18	2/27/19	02/2020
SUVI L1b Product			
Solar EUV Imagery	8/21/18	4/3/19	02/2020
MAG L1b Product			
Geomagnetic Field	8/8/18	1/24/19	02/2020

Validation Maturity Levels: Not Validated | Beta Maturity | Provisional Maturity | Full Maturity

When Will G17 Data be Available to the Public?

All (near-term) dates subject to change!

ABI L2+ Products	Beta	Prov	Full
Cloud and Moisture Imagery (CMI) and Sectorized CMI (KPP)	8/27/18	11/28/18	2019
Aerosol Detection (Smoke & Dust)	8/27/18	3/20/19	2020
Aerosol Optical Depth (AOD)	8/27/18	12/18/19	2020
Clear Sky Mask	8/27/18	6/19/19	2020
Cloud Optical Depth	8/27/18	9/25/19	2020
Cloud Particle Size Distribution	8/27/18	10/9/19	2020
Cloud Top Height	8/27/18	3/20/19	2020
Cloud Top Phase	8/27/18	7/17/19	2020
Cloud Top Pressure	8/27/18	3/20/19	2020
Cloud Top Temperature	8/27/18	3/20/19	2020
Derived Motion Winds	8/27/18	5/9/19	2020
Derived Stability Indices	8/27/18	11/27/19	2020

ABI L2+ Products	Beta	Prov	Full
Downward S/W Radiation: Surface	8/27/18	9/25/19	2020
Fire/Hot Spot Characterization	8/27/18	9/4/19	2020
Hurricane Intensity Estimation	8/27/18	N/A	N/A
Land Surface Temperature	8/27/18	12/5/19	2020
Legacy Vertical Moisture Profile	8/27/18	11/27/19	2020
Legacy Vertical Temperature Profile	8/27/18	11/27/19	2020
Rainfall Rate/QPE	8/27/18	9/18/19	2020
Reflected S/W Radiation: TOA	8/27/18	9/25/19	2020
Sea Surface Temperature	8/27/18	3/20/19	2020
Snow Cover	TBD*	TBD*	TBD*
Total Precipitable Water	8/27/18	11/27/19	2020
Volcanic Ash: Detection and Height	8/27/18	7/17/19	2020

Validation Maturity Levels: Not Validated | Beta Maturity | Provisional Maturity | Full Maturity

* Snow Cover has a waiver. It is dependent upon a non-baseline Albedo Product which is in development.

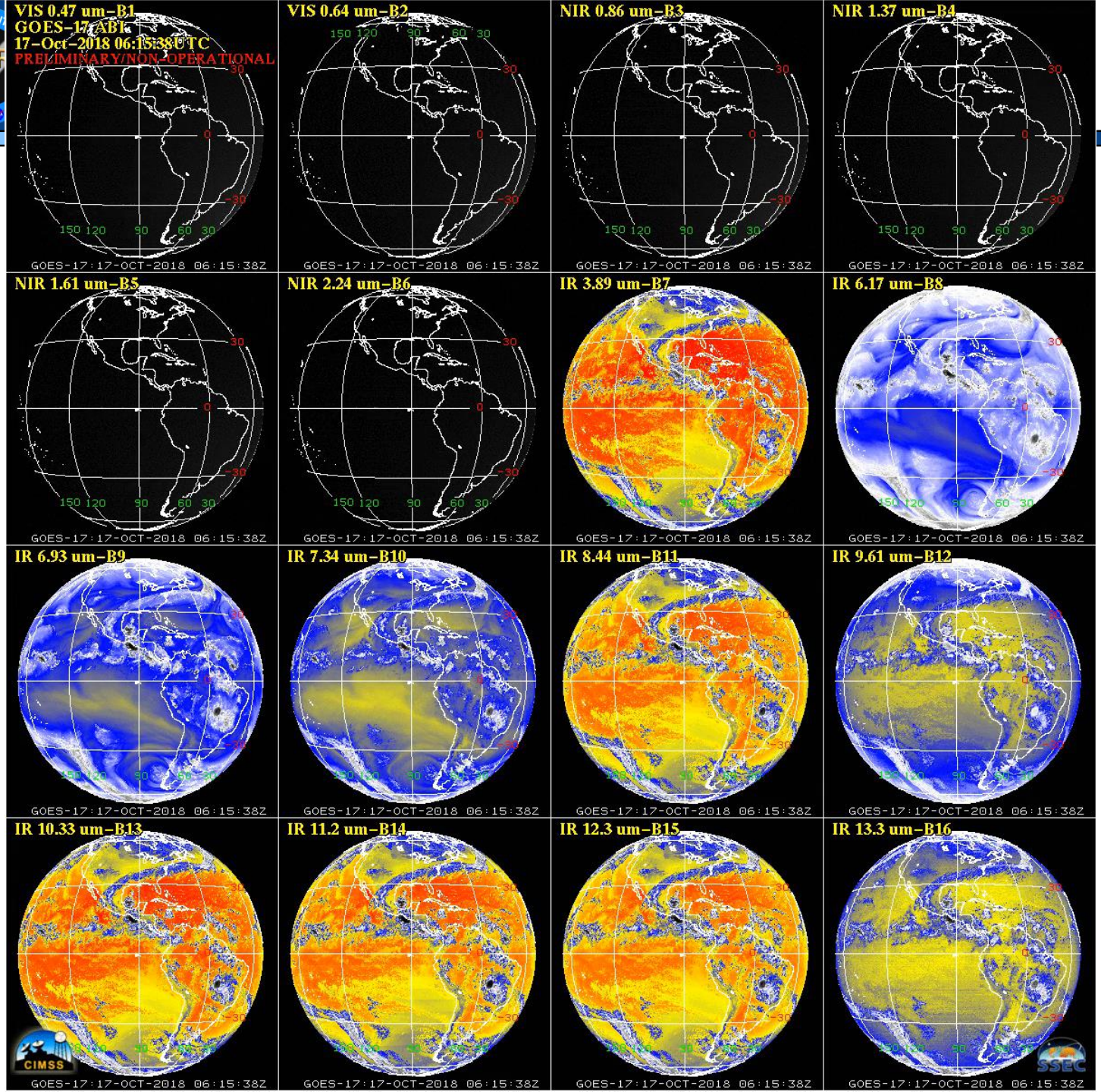
GOES-17 ABI Performance

- Loop Heat Pipes on GOES-17 ABI not functioning properly
  - Loop Heat Pipes are not transferring expected thermal load to radiator
  - Results in loss of data from 7 infrared channels at warmest orbital conditions (before and after the vernal and autumnal equinoxes)
    - Water vapor (Ch 8, 9, 10), cloud top phase and ozone LWIR (Ch 11, 12), dirty and CO2 LWIR (Ch 15, 16)
  - Under worst case conditions, local emission and dark current noise cause the longer wavelength channels to saturate and become unusable for 3-6 hours overnight depending on channel

- Optimization techniques successful in recovering > 97% of planned ABI data
  - Operating IR detectors and cryocooler at higher set points
  - Reducing detector integration time and optimizing gain/bias settings
  - Performing semi-annual yaw flip to reduce solar load

- ABI recently experienced a software error that resulted in degraded imagery
  - Not due to ongoing loop heat pipe issue
  - Recent update to software that controls the ABI cryocooler system experienced a memory error
  - Cryocooler operation was restored; imagery degradation was temporary and no longer expected
  - ABI engineers testing permanent software fix, to be implemented in January

https://www.goes-r.gov/users/transitionToOperations17.html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GOES-17 ABI
17-Oct-2018 06:15:38 UTC
PRELIMINARY/NON-OPERATIONAL
VIS 0.64 um-B2
NIR 0.86 um-B3
NIR 1.37 um-B4
NIR 1.61 um-B5
NIR 2.24 um-B6
IR 3.89 um-B7
IR 6.17 um-B8
IR 6.93 um-B9
IR 7.34 um-B10
IR 8.44 um-B11
IR 9.61 um-B12
IR 10.33 um-B13
IR 11.2 um-B14
IR 12.3 um-B15
IR 13.3 um-B16
GOES-17:17-OCT-2018 06:15:38Z
CIMSS
SSEC

Post-Launch Product Tests: ABI

System Performance Characterization:

- Restricted Zone Performance (Solar Avoidance), A/D Converter, RVS, Band-to-band, SRF & OOB performance, etc.

VNIR Calibration:

- SD Calibration, Lunar Observations, Desert Site Trending, Satellite Intercomparisons.

IR Calibration:

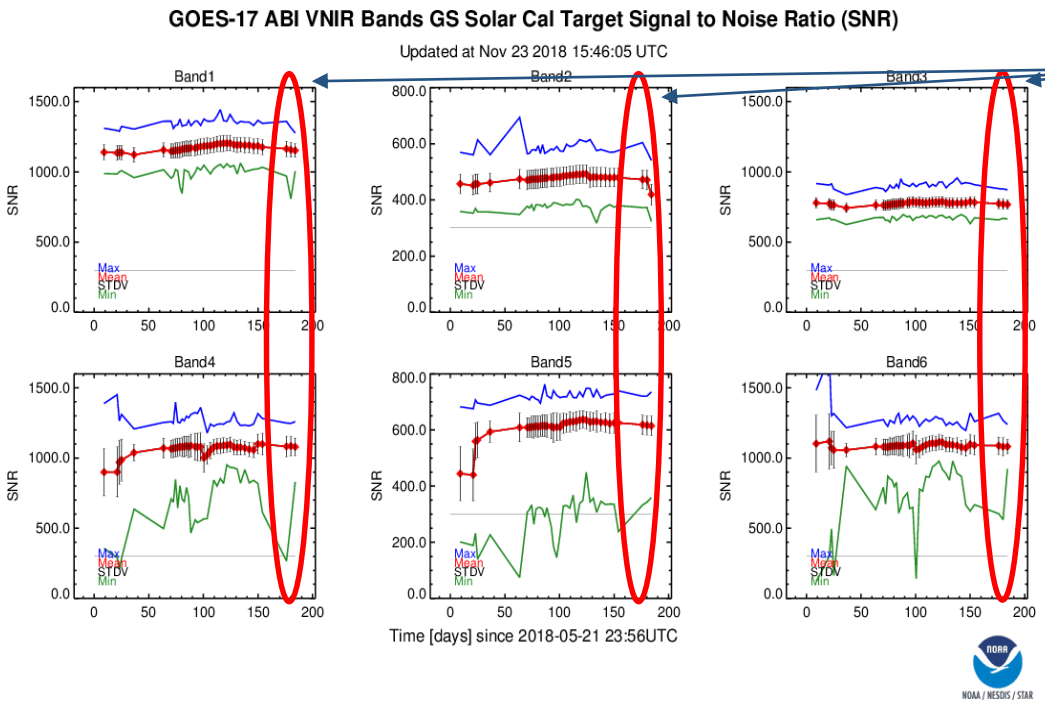
- BB Trending (ICT), Satellite Intercomparisons, CRTM.

INR Calibration:

- Navigation, Co-registration, and Stitching Assessments.

VNIR Noise Stability
Pre- and post-drift

Post-Drift



ABI L2+ LHP Mitigation Strategy

- Due to the LHP anomaly, Program and STAR are working towards implementing
  - FPM temperature based DQFs
  - Band swapping based on the DQF
    - For example, implementing logic to swap B13 for B14 in the Fires algorithm
  - Enterprise Algorithms: updated science and dynamic band swapping

- The review process after implementing these updates reflects resource prioritization. The reviews are scheduled in precedence and readiness order from March 2019 through December 2019.

Post-Launch Product Tests: GLM

- Goal of GLM PLPTs are to verify the system Detection Efficiency, False Alarm Rate, and INR quality over full range of seasonal effects.
- Detection efficiency is meeting specifications (70%), but a lookup table update recently installed improved it even more.
- Provisional review on December 20 confirmed improvements in detection efficiency and false alarm rate. Data allowed to become public after the Provisional declaration.

<u>System Performance Characterization (PLTs):</u>

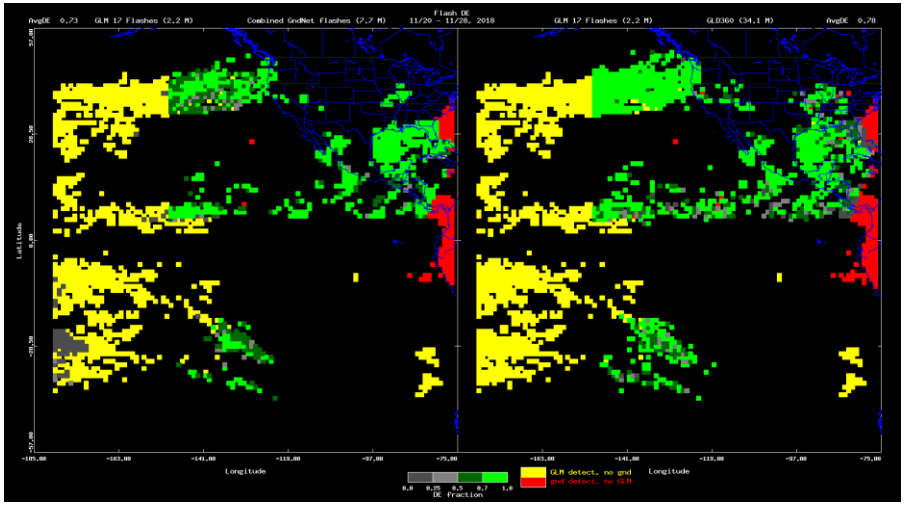
Timing Settings, Image Quality, Lightning Threshold Settings, Solar Intrusion Criteria Verification, INR Performance, Alignment Assessment

<u>Intercomparision with Ground-based and Space-based Lightning Detection Systems:</u>

Very Long-, Long-, Medium-, and Short-range Networks, Optical-based Networks, Electric Field Networks, and Orbital (ISS-LIS, TARANIS *(2018)*)

<u>Laser Beacon Campaign</u>

Combined Networks GLD360



Spatially Averaged DE: 73% 88%

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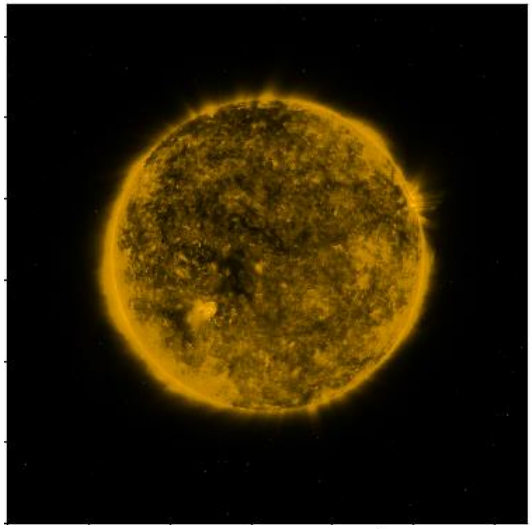
Post-Launch Product Tests: GOES-17 SUVI L1b

- GOES-17 SUVI is performing in family with GOES-16 SUVI
  - Based on results from PLPTs (G16 intercomparison, Detector Characterization and Trending, Intercomparison with SDO AIA & EVE and with legacy GOES EUVS and GOES-R EXIS EUVS)

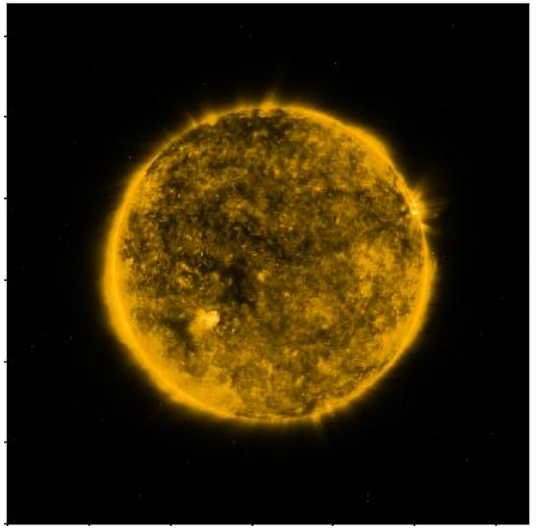
- During PLT, underwent a unique test to experiment with operating in a non-nominal scan mode, utilizing a 9-point scan slew to image the entire extended coronagraph. Results were very encouraging!
  - For more info see presentation on Thursday: SH34A-09: Coronal Imaging Campaign with SUVI (Kumar Tadikonda)

- Due to a minor issue with image navigation in the yaw-flipped orientation, the Provisional maturity review will be held after the spacecraft flips back to upright in the end of March. Meanwhile, the navigation issue is being addressed by an upcoming software release.

GOES-16 SUVI 171Å



GOES-17 SUVI 171Å



GOES-17 MAG L1b Status at Beta Maturity

- Initial biases are reasonable (~5 nT)
- Sensitivity to interference
  - Arcjet firings cause a significant problem. At Beta, noise and bias did not meet requirements. Arcjet flags are now in place to aid manual removal of signature from data; arcjet correction algorithm in work.
- Inboard/outboard differences
  - Long-term drift (5 nT) exceeds 1.7 nT accuracy requirement
  - Inboard MAG anomaly exceeds 1.7 nT bias requirement (~6 nT shift)
    - Validation analysis will continue with Outboard MAG only
- On track for Provisional maturity in January 2019 (or soon thereafter based on shutdown)

GOES-17 SEISS & EXIS L1b Data at Beta Maturity

EXIS:

- Detector Characterization, Image Quality, Degradation Trending, Intercomparison to GOES-R SUVI, XRS & EUVS on legacy GOES, SDO AIA & EVE, TIMED SEE, GOME2A, 2B, SORCE SOLSTICE, etc.
- A dedicated space weather software update is being installed in the Ground System to get EXIS to Provisional maturity in February 2019 (or soon thereafter).
- EXIS PLPTs will begin once the new software update is installed.

SEISS:

- System checks, internal cross-comparisons, contamination corrections, background trending, satellite intercomparisons. PLPTs are underway for all 4 sensors.
  - Since we're at a minimum for solar activity, galactic cosmic rays are being used in validation efforts instead of solar particle (proton) events.
- MPS-HI L1b Product declared at Provisional maturity December 18, 2018.
- SGPS, EHIS, and MPS-LO Provisional maturity coming in next few months

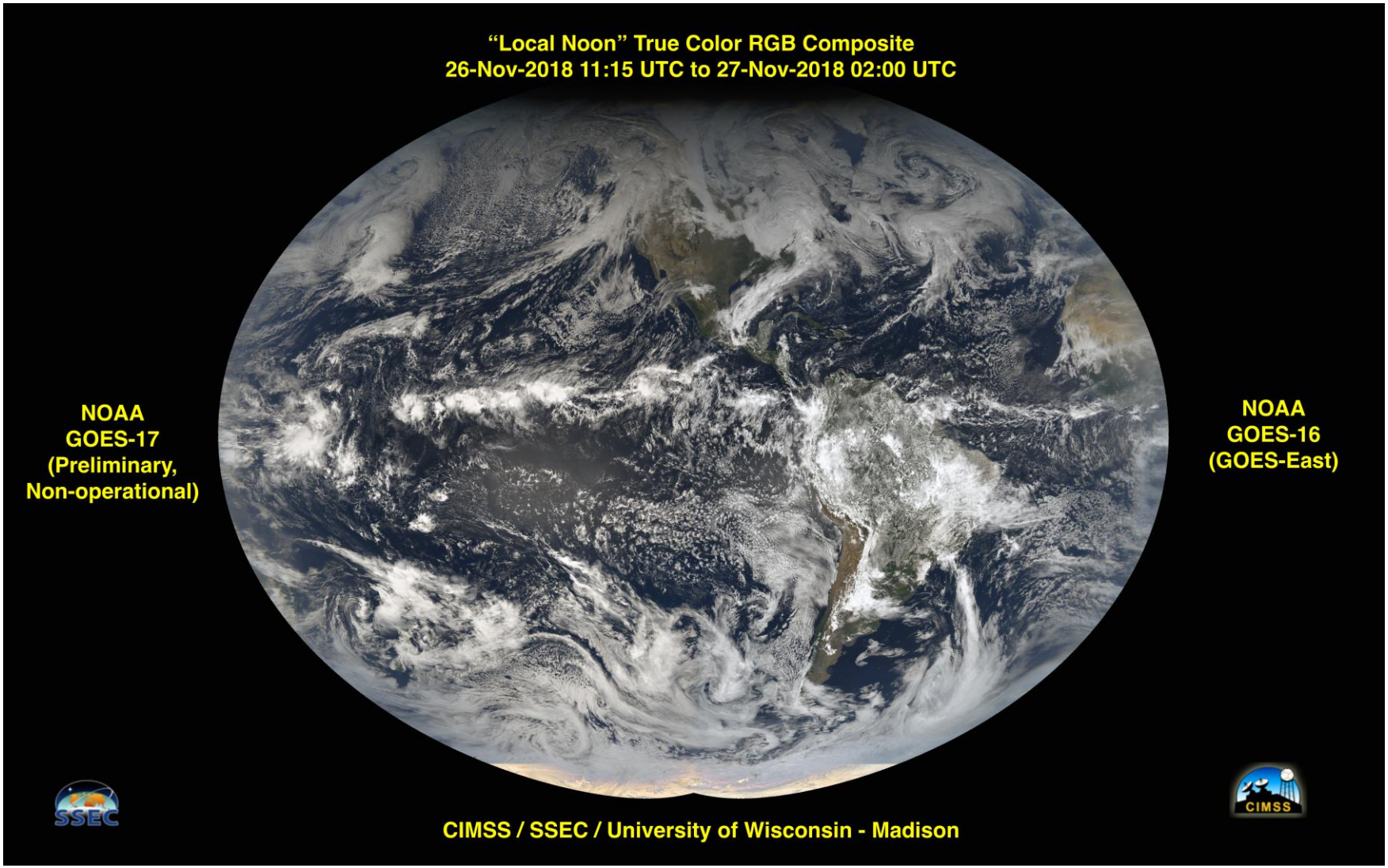
GOES-17 Transition to Operations

- GOES-17 transition to operations as NOAA's GOES West is delayed
  - Originally scheduled for December 10, 2018
  - GOES-17 continues checkout from 137.2 degrees west longitude
  - Due to cryocooler software issue experienced in November. Problem now fixed.
  - Transition to GOES West will be delayed until January 2019
  - GOES-15 will operate in tandem with GOES-17 for at least 6 months to allow for assessment of the performance of GOES-17 as the GOES West operational satellite.
  - GOES-15 moved to 128 degrees west to eliminate radio frequency interference with GOES-17

- GOES-15 (GOES West and GOES-16 (GOES East)) remain healthy and continue to provide operational coverage of the Western Hemisphere
  - Slight delay in transitioning GOES-17 to operations will not adversely impact ongoing NOAA operations

https://www.goes-r.gov/users/transitionToOperations17.html
Note that Web Page is not being updated during Shutdown!

G16 & G17 Mollweide Projection



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GOES-T and GOES-U Status

- ABI radiator is being redesigned for GOES-T and GOES-U to reduce risk of cooling system anomalies seen on GOES-17
- GOES-T:
  - Environmental testing on hold pending ABI radiator redesign
  - Due to redesign, planned May 2020 GOES-T launch date will be delayed
  - Once new radiator design is approved, a new launch date will be determined
- GOES-U:
  - Preparing to add NRL's Compact Coronagraph for coronal mass ejection detection (follow-on to SOHO), pending funding approval
    - CCOR Preliminary Design Review completed in September
  - Launch planned for 2024

Thank you!

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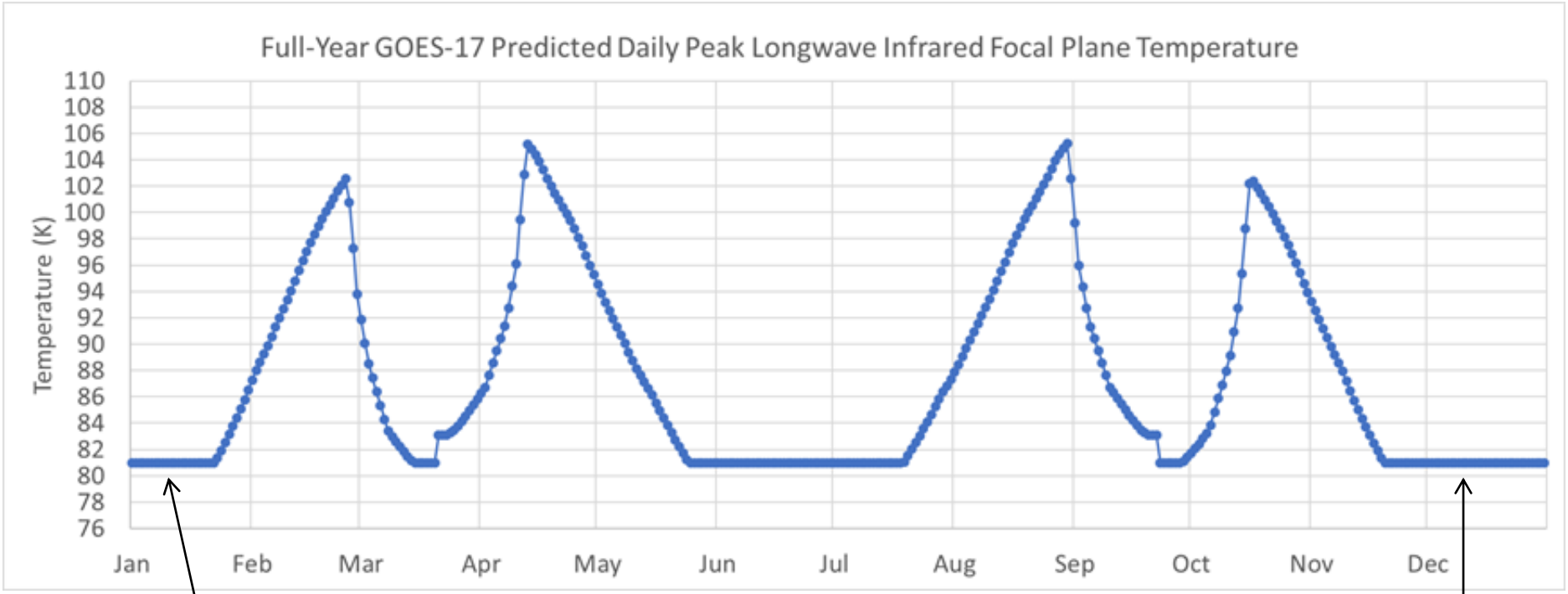
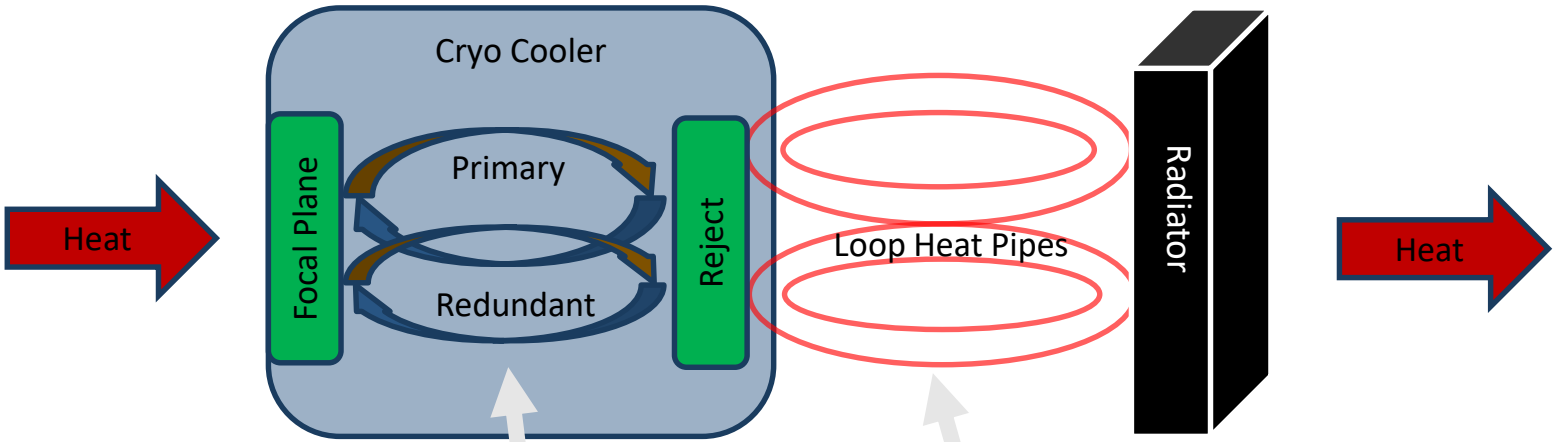
Annual Fluctuation of FPM Temperatures



G17 baseline operating temperature is 81 K, nominally is 60 K

We are here, in our twice annual 'cool period'

Cryocoolers & LHP Model



Cryocoolers take heat from the ABI focal plane module (FPM) to a reject surface

Heat pipes pick up the heat and deliver it to the radiator

Both cryos are required to maintain FPM temperature

December 18, 2017