Ground System Webinar

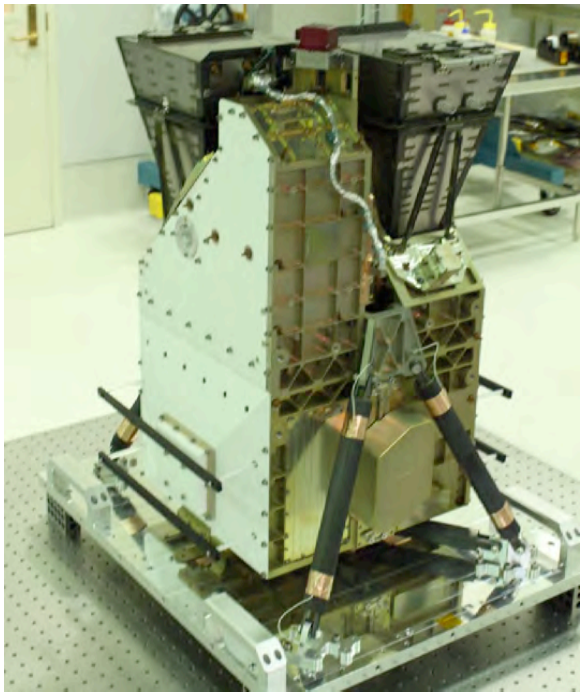
How Data Gets from the GOLD Instrument to Publicly Available Science Data Products

Feb. 27, 2019

Karen Bryant

GOLD Instrument Overview

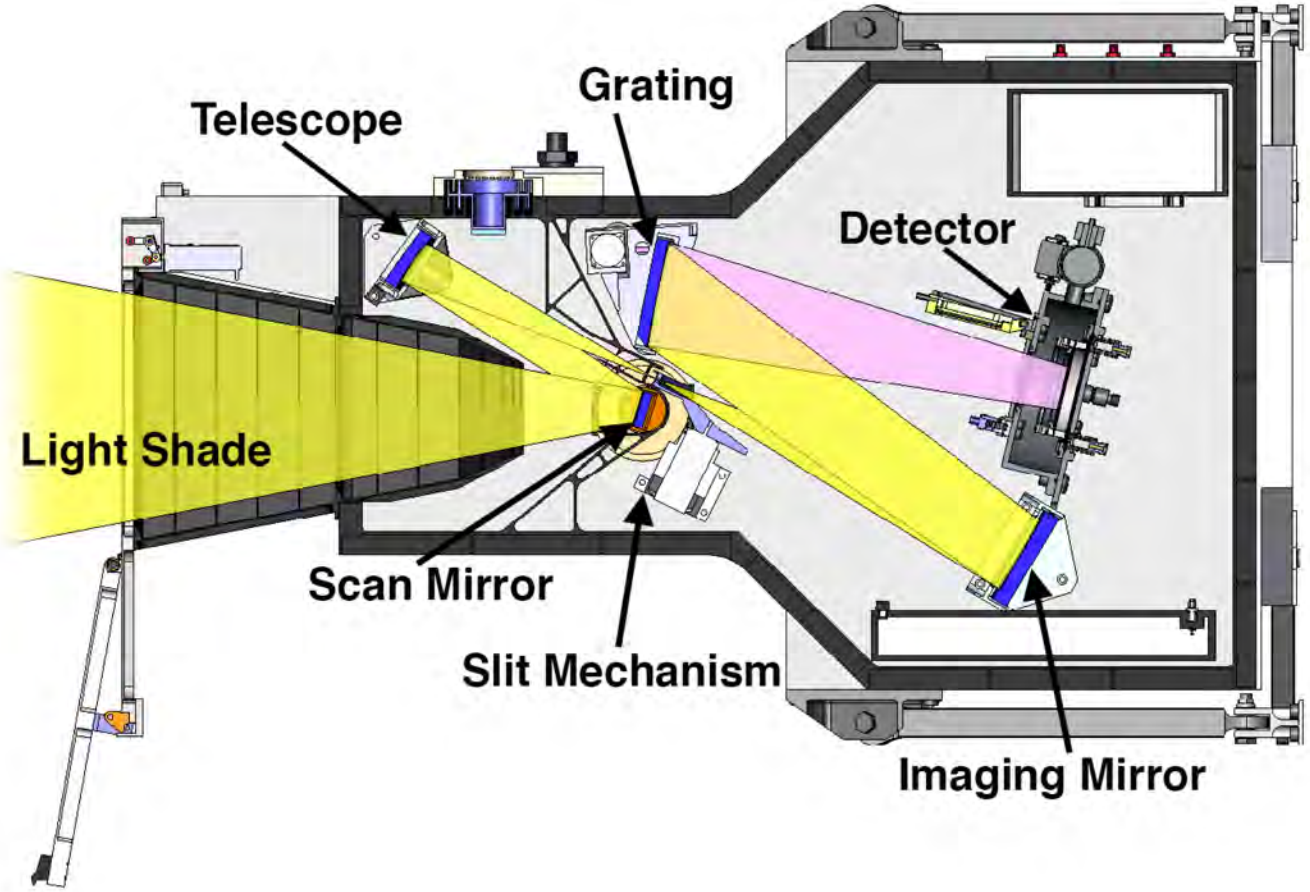
- GOLD = Global-scale Observations of the Limb and Disk
- Ultraviolet imaging spectrograph
  - Built by the University of Colorado Boulder's Laboratory for Atmospheric and Space Physics (LASP)
- Imager observes Earth's limb and disk at 131-160 nm



GOLD Instrument

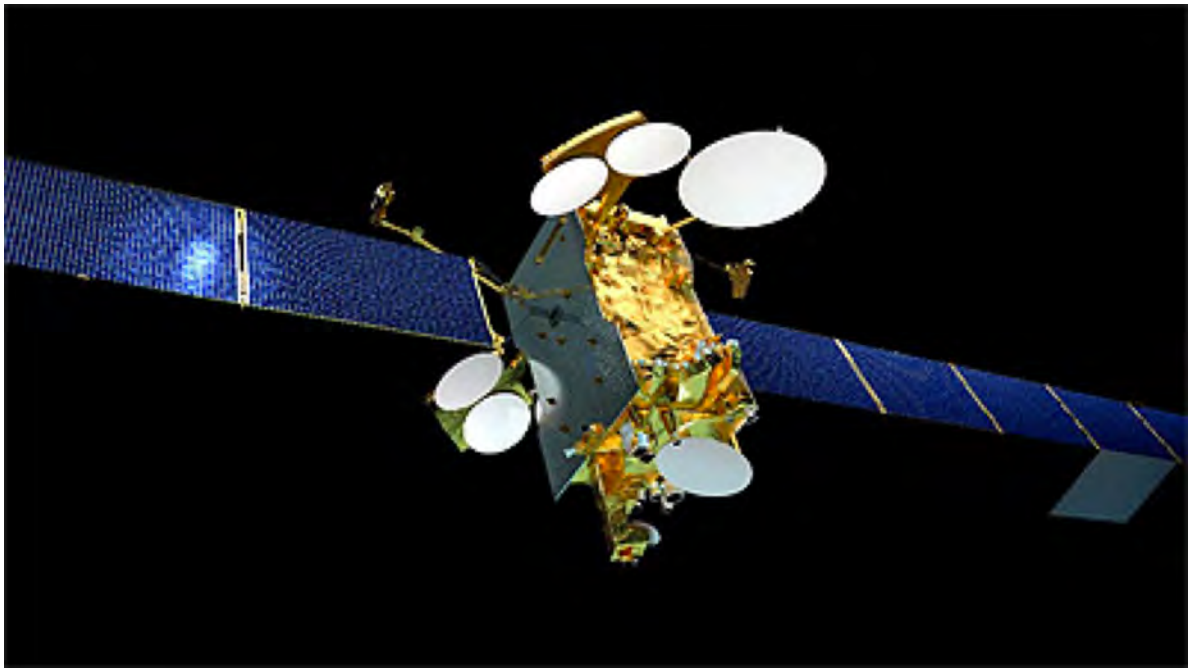
GOLD Instrument on SES-14

GOLD Instrument Diagram



SES 14

- GOLD is hosted on the SES-14 satellite
  - 1st NASA science mission hosted payload
- SES-14 is a commercial communications satellite
  - SES owns and operates the satellite
  - Airbus Eurostar 3000
  - Geostationary orbit at 47.5° West



Launch

- SES-14 launched
  - Jan 25, 2018 at 7:20 pm
  - Ariane 5 launch vehicle
  - From Kourou, French Guiana

Launch Pictures

Orbit Raising

- SES-14 is using electric propulsion
  - Orbit raising
  - Station keeping maneuvers
- Reached geostationary orbit around July 16, 2018

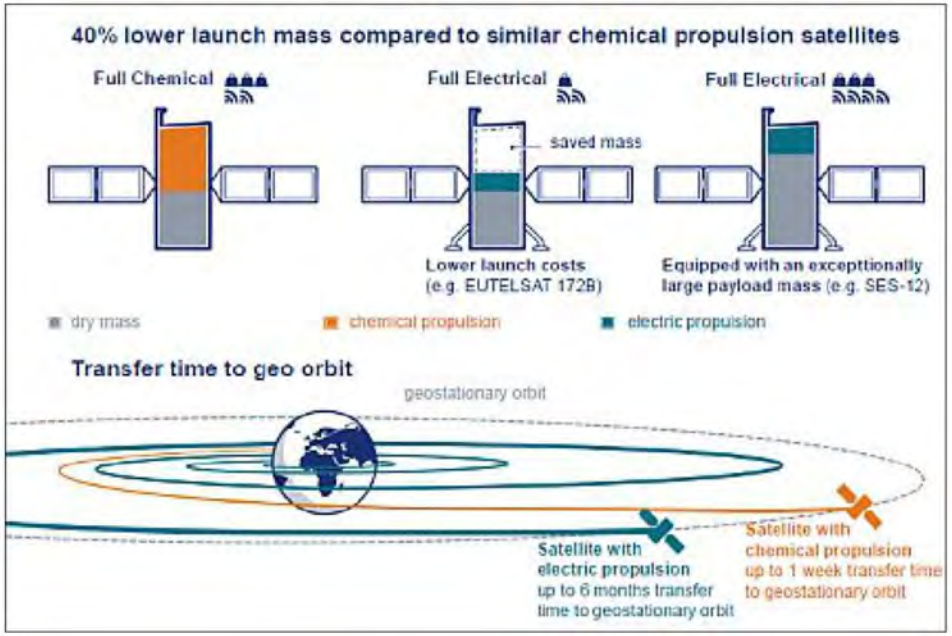


Image credit: Airbus DS

Commissioning to Nominal Ops

- SES-14 (spacecraft)
  - Commissioned throughout August
- GOLD
  - Powered on Sept. 4, 2018
  - Commissioning complete: Oct. 16, 2018
  - Began nominal operations Oct. 17, 2018
- Level 1 public data products
  - Targeting release to the GOLD website on March 1
- Level 2 public data products
  - Targeting release to the GOLD website on April 1

GOLD Ground Segment

SES Satellite Control Center (SCC)
[*Luxembourg*]
S/C Ops & Instrument Cmd

SES GS GOLD Ground Station (GGS)
[*Woodbine, MD*]
High-rate telemetry

SES / SES GS

GOLD Science Centers (GSC)

CU/LASP Science Operations Center (SOC)
[*Boulder, CO*]
Instrument ops, plan, command, monitoring
L0, L1A generation,
L1 algorithms

UCF Science Data Center (SDC)
[*Orlando, FL*]
L1B-D & L2 product generation
L0 – L2 Archive

Science Data Users
GOLD Co-Is, Science Community, SPDF

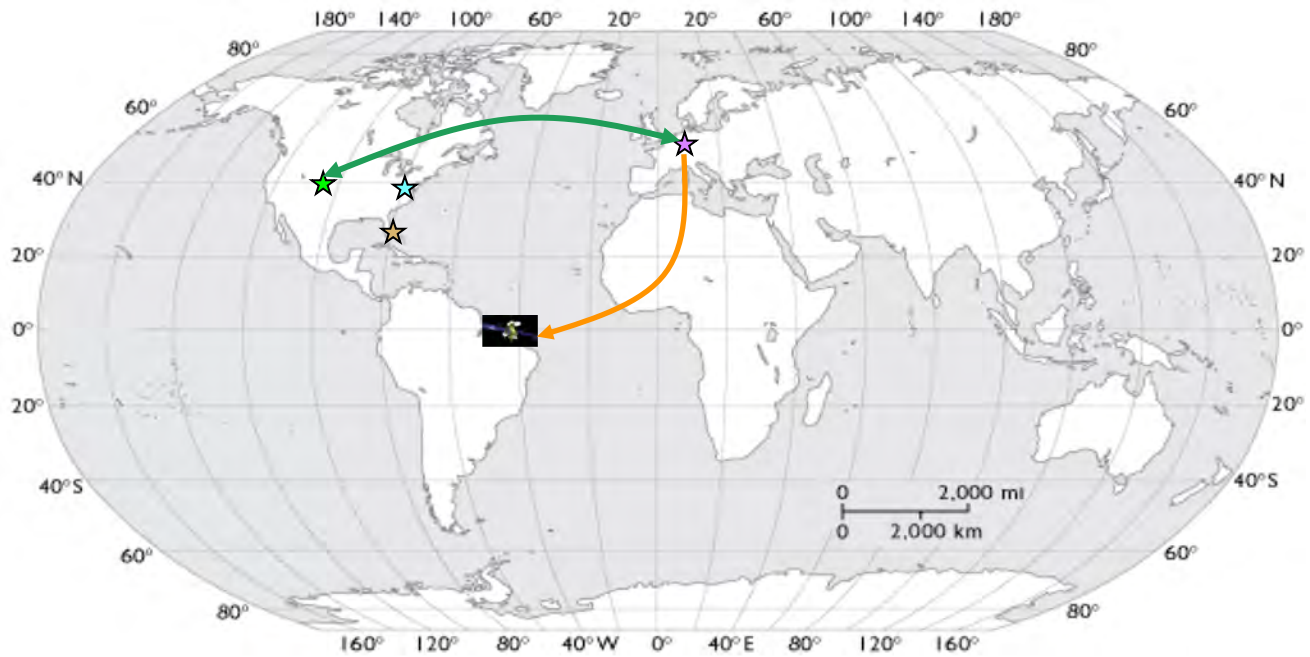
Command Uplink

- S-band for command uplink

- Command files originate in Boulder, CO at the Science Operations Center (SOC)
- Command files arrive in Luxembourg
- Command files are converted to binary packets and are uplinked to the spacecraft
- Spacecraft routes the commands to GOLD instrument

Photo credit - SES
https://www.ses.com/media-gallery/ses-operations

Command Data Path



- SES-14 – Geostationary orbit at 47.5° West
- Science Operations Center (CU/LASP) - Boulder, CO
- Satellite Control Center (SES) – Luxembourg City, Luxembourg
- GOLD Ground Station (SES GS) – Woodbine, MD
- Science Data Center (UCF) - Orlando, FL

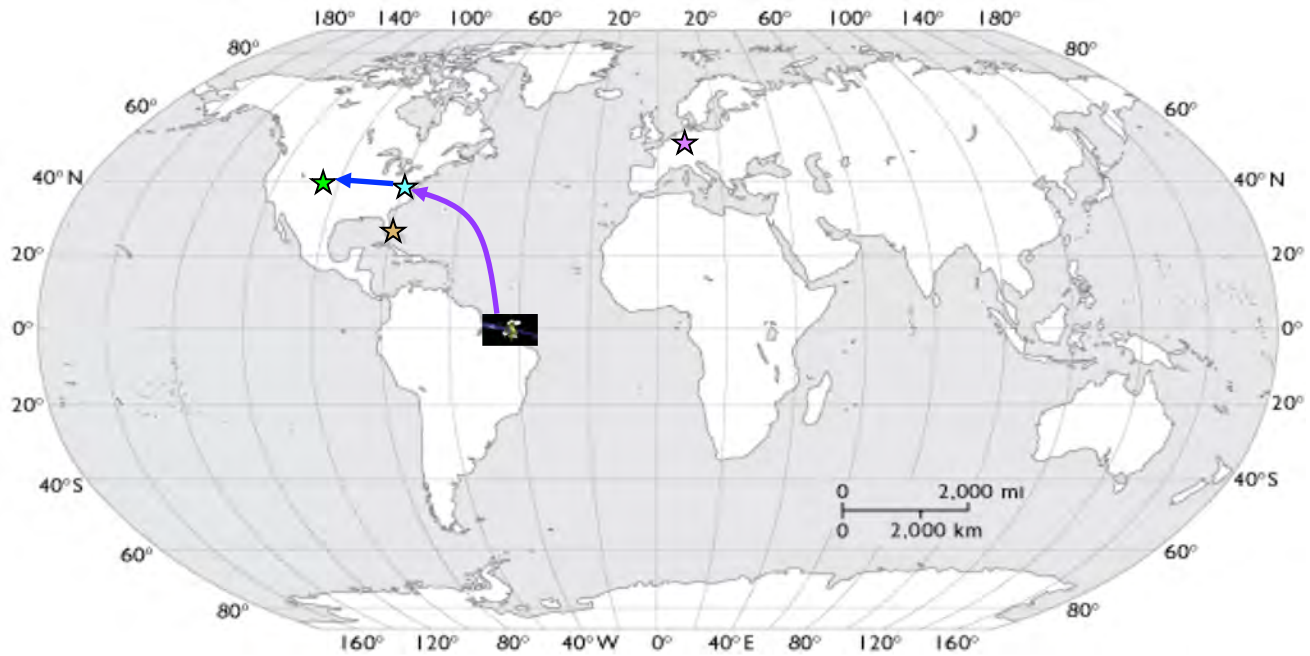
- Commands and ancillary data (internet)
- S-band uplink

Telemetry Downlink

- Ka-band for telemetry (science and instrument health and safety data) downlink
  - 6 Mbits/second GOLD data downlink

- Telemetry are sent from the GOLD instrument to the Spacecraft
  - Spacecraft routes the telemetry through antenna
- Received at Ground Station antenna (Woodbine, Maryland)
  - Converted from analog to digital signal
  - Transferred via internet to Science Operations Center (SOC) in Boulder, Colorado

Telemetry Data Path



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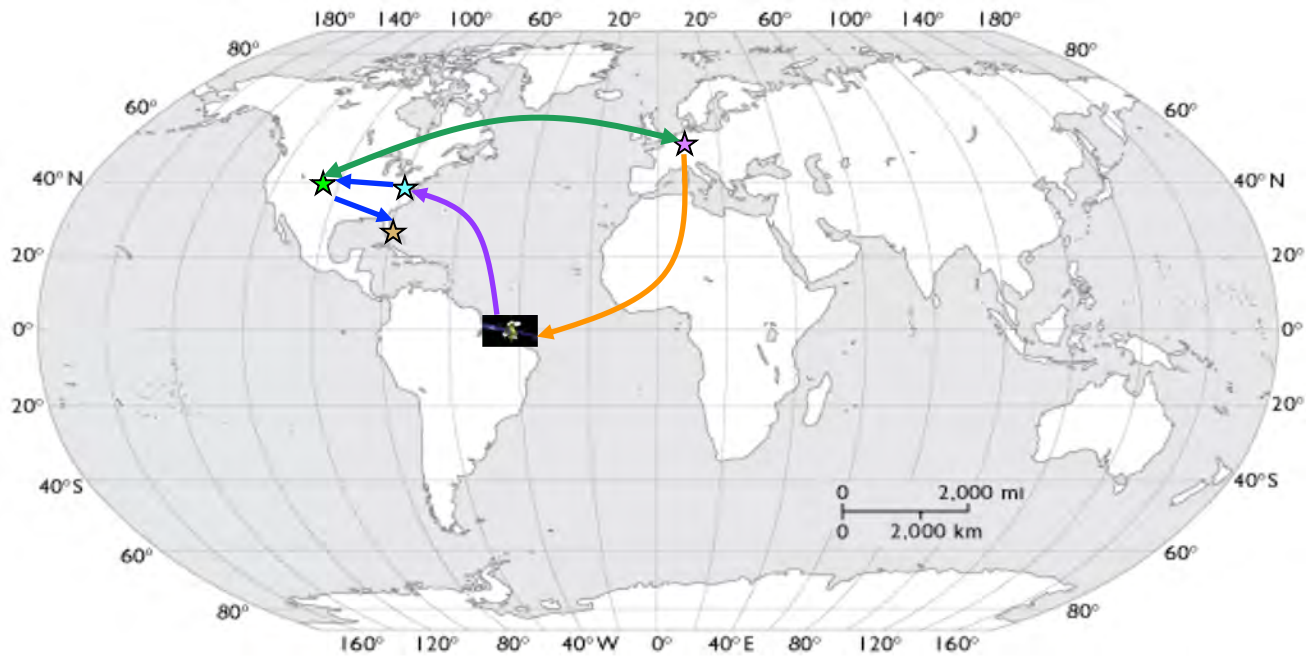
- Ka-band downlink
- Science and housekeeping data (internet)

Telemetry to Science Data Products

- Telemetry arrives as packets in Boulder, CO at the Science Operations Center (SOC)
- SOC converts science packets with raw values into Level 1A NetCDF files containing converted values (engineering units)
  - For example a raw value of 1234 is converted into a voltage of 5.1 V
- SOC transfers the Level 1A science files to the Science Data Center (SDC) at the University of Central Florida (UCF) in Orlando, FL
- The SDC processes the Level 1A science files into higher level science data products

Level	Description
1B	Data binned and mapped in GOLD coordinates, with geolocation information included. Converts time series of photon events into an image data cube.
1C	Geolocated data in both counts and brightness (calibrated) units. Includes backgrounds and brightness total error. Data are further binned spatially and spectrally.
1D	Images of disk brightness at key wavelengths.
2	Daily files produced for each geophysical data product.

End to End Data Path



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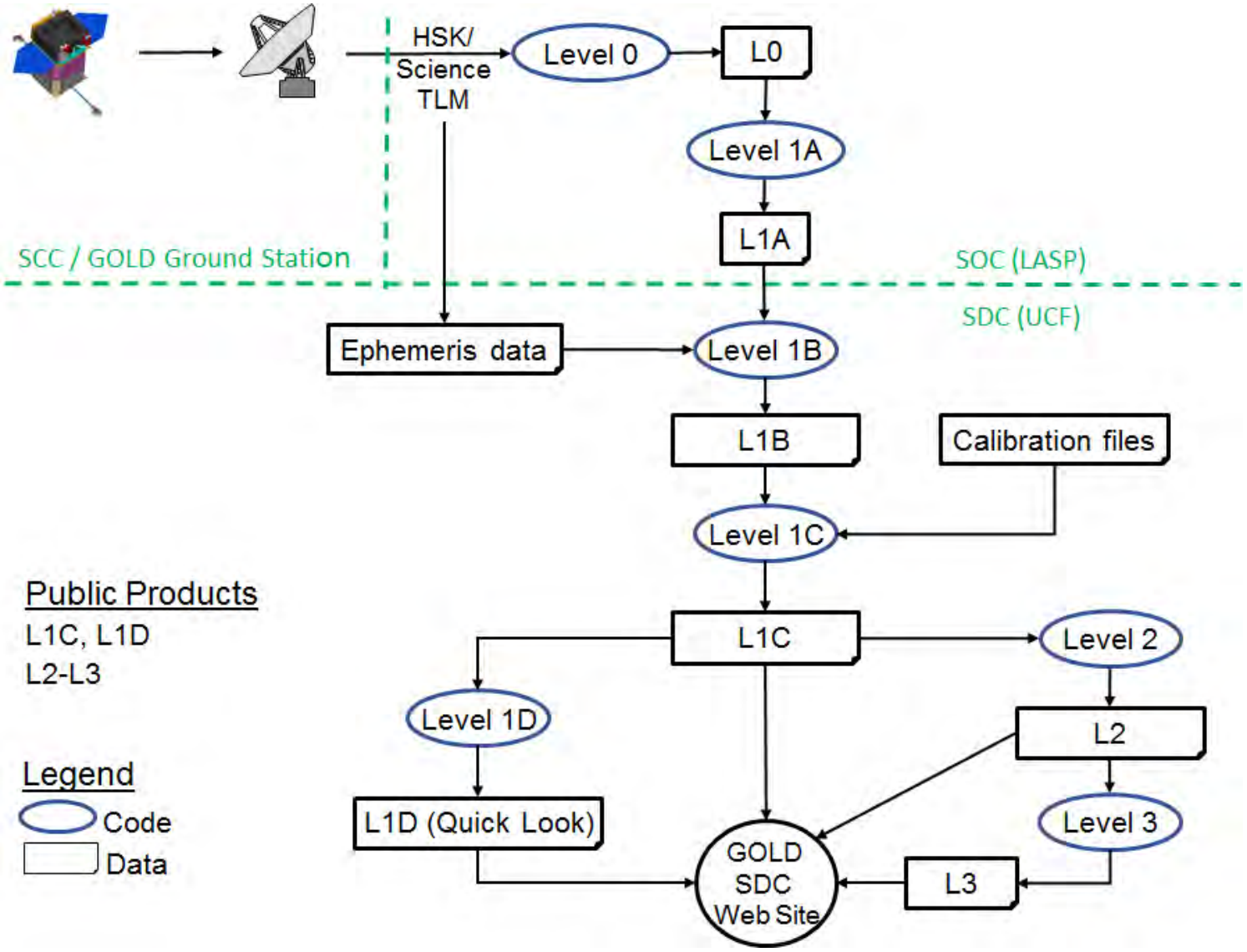
- Commands and ancillary data (internet)
- S-band uplink
- Ka-band downlink
- Science and housekeeping data (internet)

Science Algorithms and Pipeline

- Science algorithm development is distributed across 2 teams
  - LASP is responsible for the Level 1 algorithms
    - Code to generate the Level 1 data products
  - Computational Physics Inc. (CPI) is responsible for the Level 2 algorithms
    - Code to generate the Level 2 data products

- University of Central Florida is responsible for science data:
  - Processing pipeline
    - Code to take incoming files, call the Level 1 code, track Level 1 file creation, call the Level 2 code, track Level 2 file creation
  - Archive
  - Distribution
    - Publicly available via GOLD web site

Science Data Flow

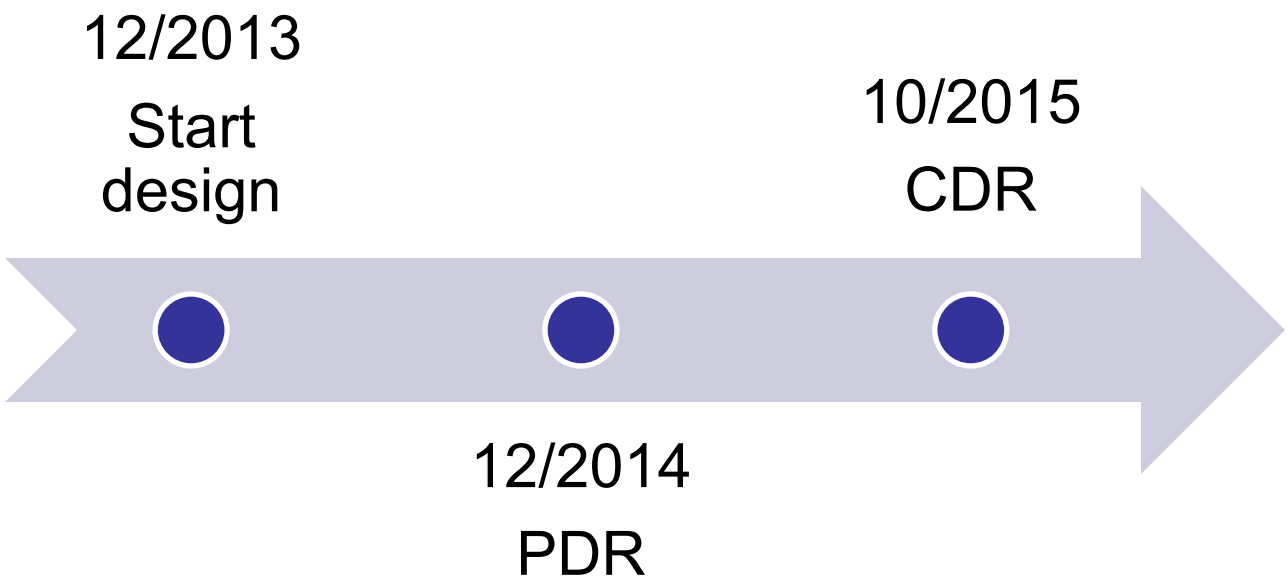


GROUND SYSTEM DEVELOPMENT AND TESTING

Or How Did We Get to Where We are Today?

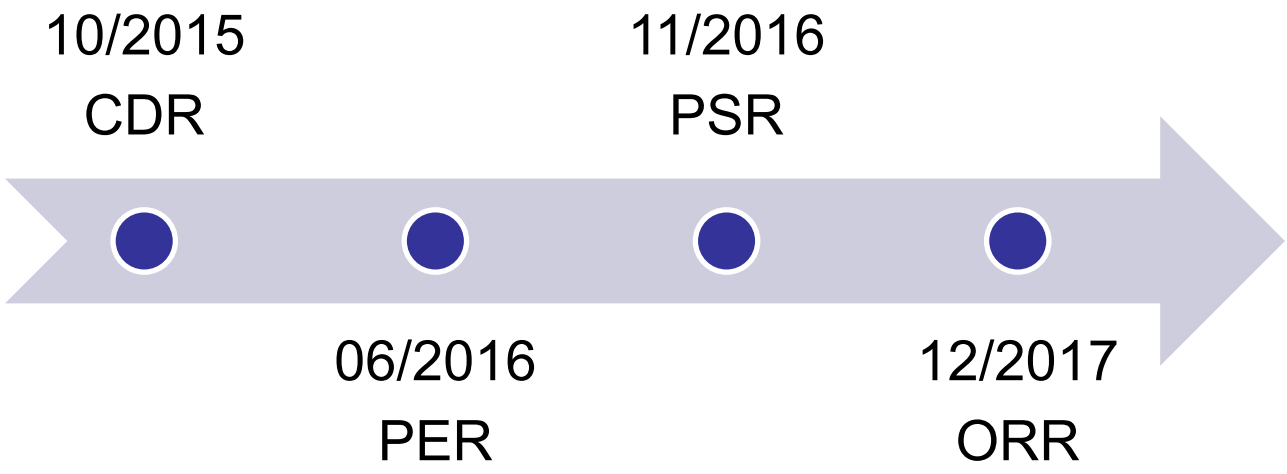
Design Phases

- Preliminary Design Review (PDR) in December, 2014
  - Ground system design started in earnest at the end of 2013
- Critical Design Review (CDR) in October, 2015
  - Design continued through 2015



Test Phases

- Pre-Environmental Review (PER) in June, 2016
  - Flight instrument ready for stand-alone environmental testing
  - Develop and test individual and integrated ground system tools
- Pre-Ship Review (PSR) in November, 2016
  - Shipped to Airbus in December, 2016 for integration on to spacecraft
  - Integrated spacecraft environmental testing
  - Finalize and test integrated ground system
- Operational Readiness Review (ORR) in December, 2017
  - End to end ground system testing complete
  - Ground system ready to support flight operations



GOLD Ground Segment Testing

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L1B-D & L2 product generation
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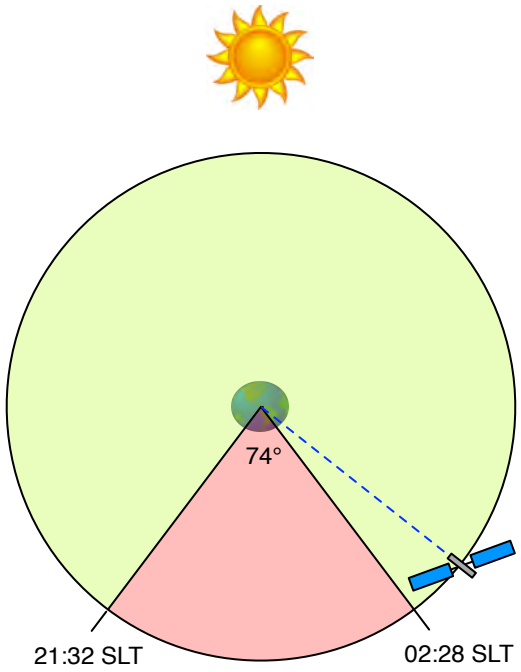
Science Data Users
GOLD Co-Is, Science Community, SPDF

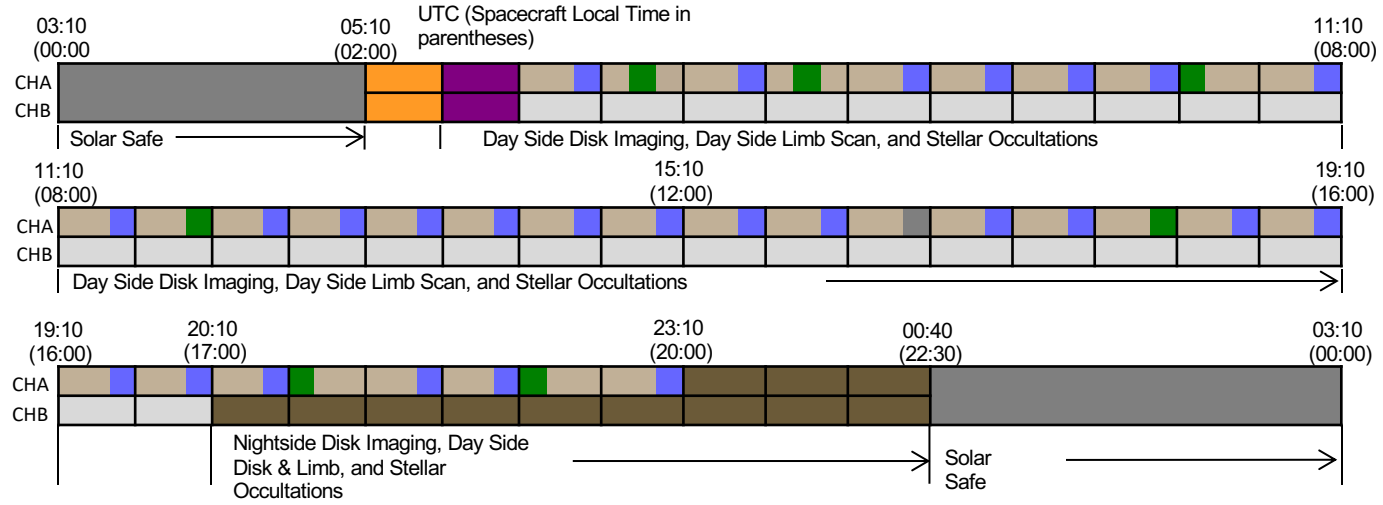
- SOC-SDC End to End
  - 02/17 – interface, archive, processing pipeline
  - 11/17 – algorithms, archive, reprocessing, interface
- GGS to SOC (10/17)
  - Connectivity, network
- SCC-SOC Data Flow (11/17)
  - Network, interface
- SCC-SOC Compatibility (11/17)
  - SOC, SCC, spacecraft
  - Tested flight scripts, comm protocol

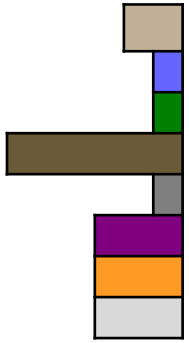
GOLD OBSERVATIONS AND PLANNING

Daily Solar Safe Times



Nominal Science Plan





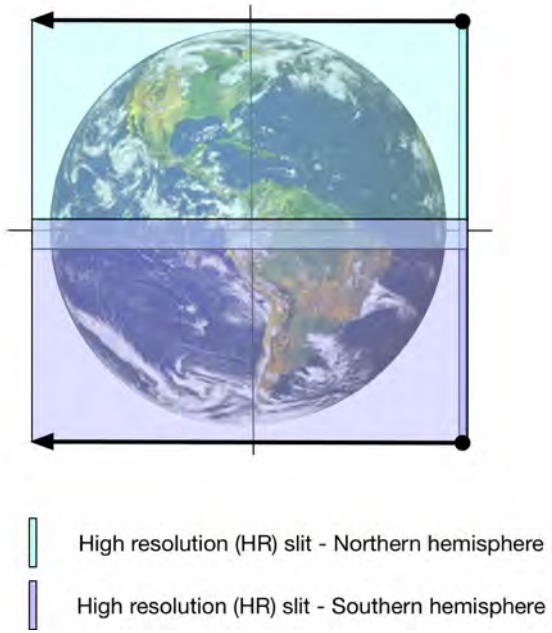
	Daily Observations	
	Channel A	Channel B
Dayside Disk Image Sequence	34	0
Dayside Limb Scan	Max: 26	0
Stellar Occultation	Max: 10	0
Nightside Disk Image Sequence	6	18
Solar Safe	-	-
Flat Fields	-	-
Detector and HV turn on	-	-
Dark		

Observation Parameters

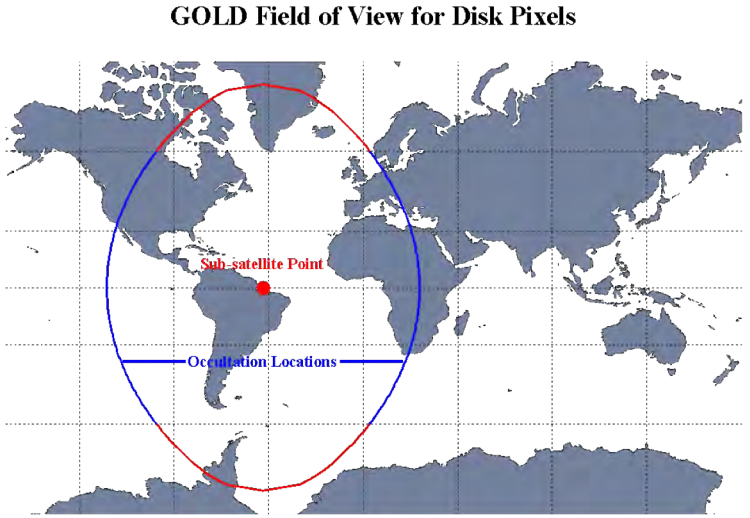
- Slit
- Start mirror position
- Step size
- Scan rate
- Scan duration

Day Disk Scans

Disk Scan



Angular coverage: 17.87˚



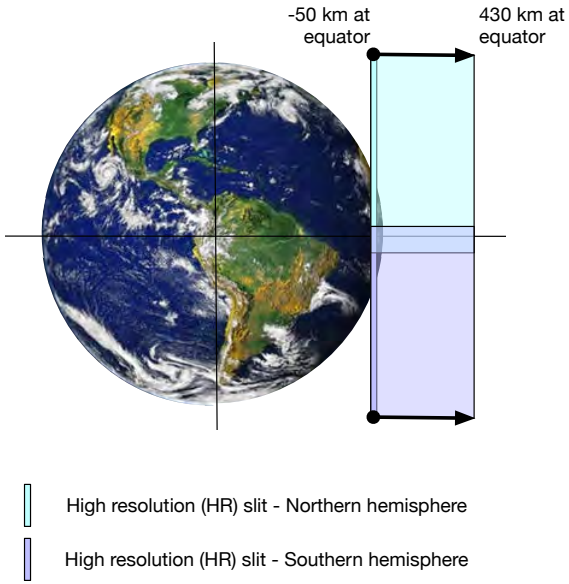
06:10:00 – 23:10:00 UTC

In 30 minute blocks, disk scans (12 minute scan/hemisphere) are either

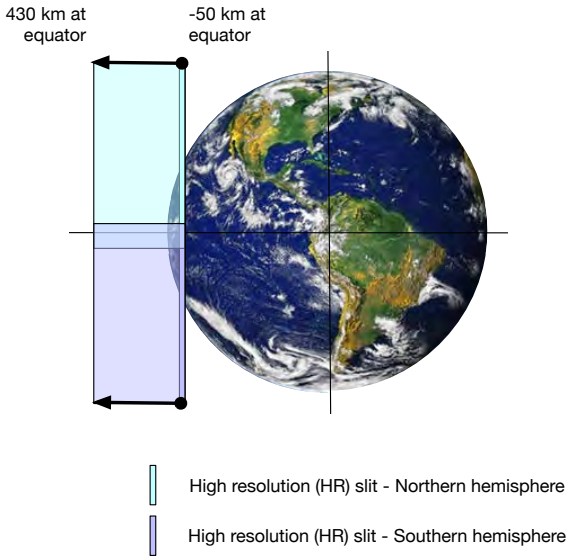
1. followed by a limb scan
2. paused/resumed by an occultation

Limb Scans

Morning (before noon SLT)



Afternoon (from noon SLT)

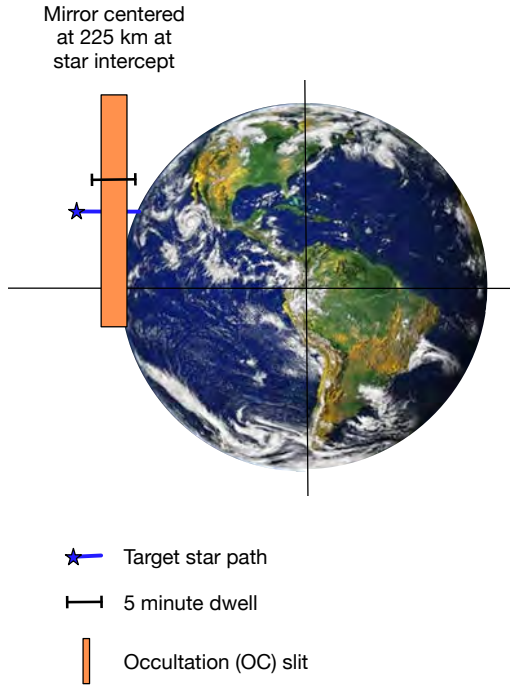


06:10:00 23:10:00 UTC

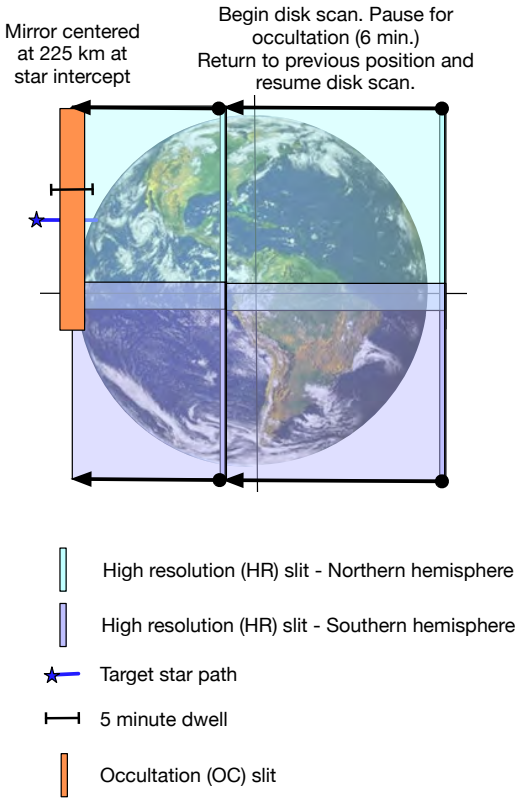
Follow disk scans in 30 minute blocks
3 minute scan/hemisphere

Occultations

Occultation



Pauses disk scan

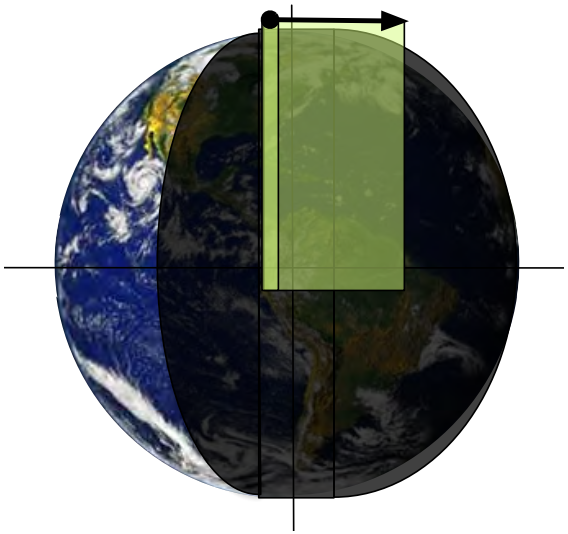


06:10:00 – 23:10:00 UTC

Pauses disk scans in 30 minute blocks
6 minute observation

Night Scans

Night Scan



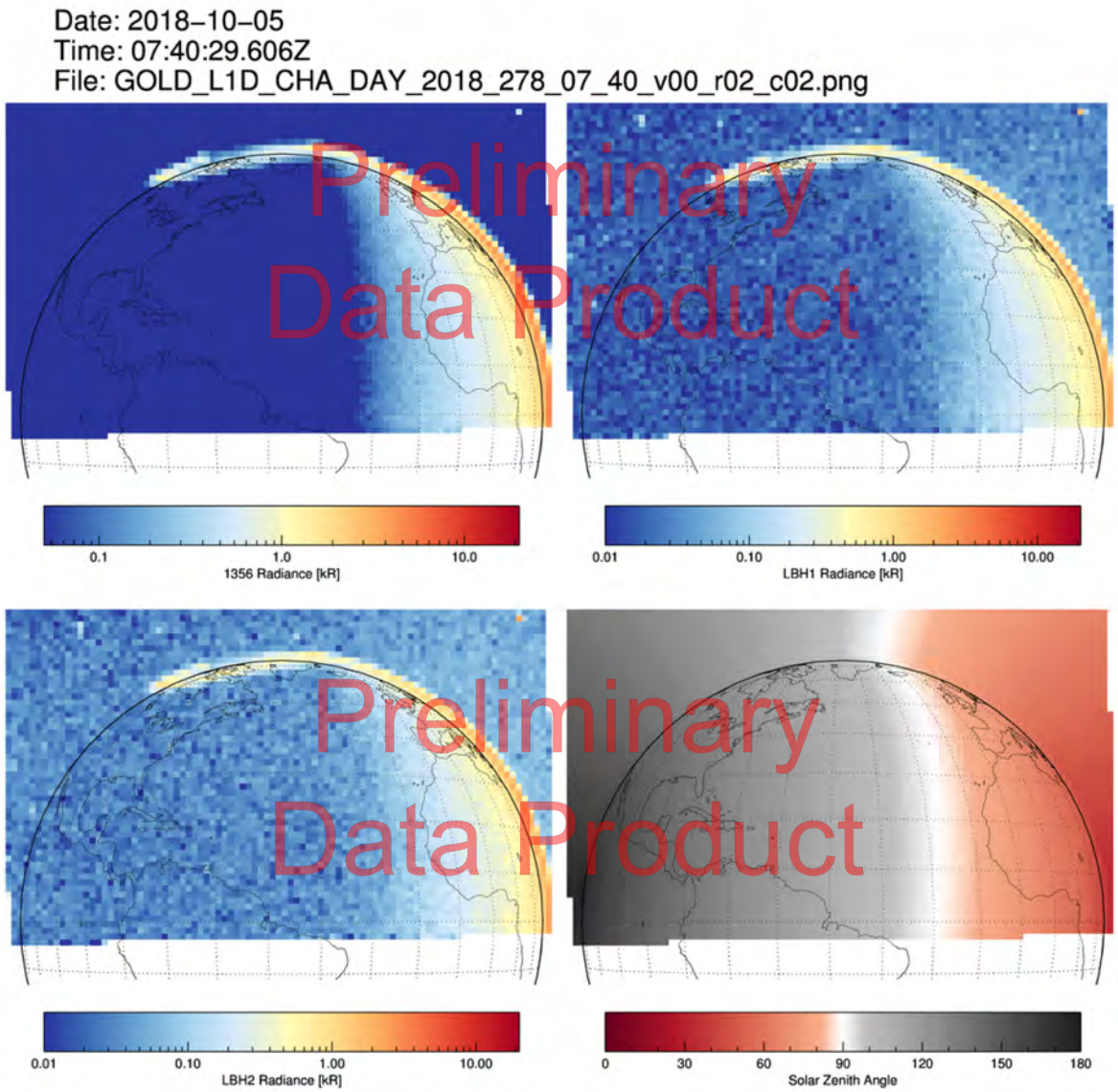
Low resolution (HR) slit

20:10:00 – 00:10:00 UTC – channel B
23:10:00 – 00:10:00 UTC – both channels

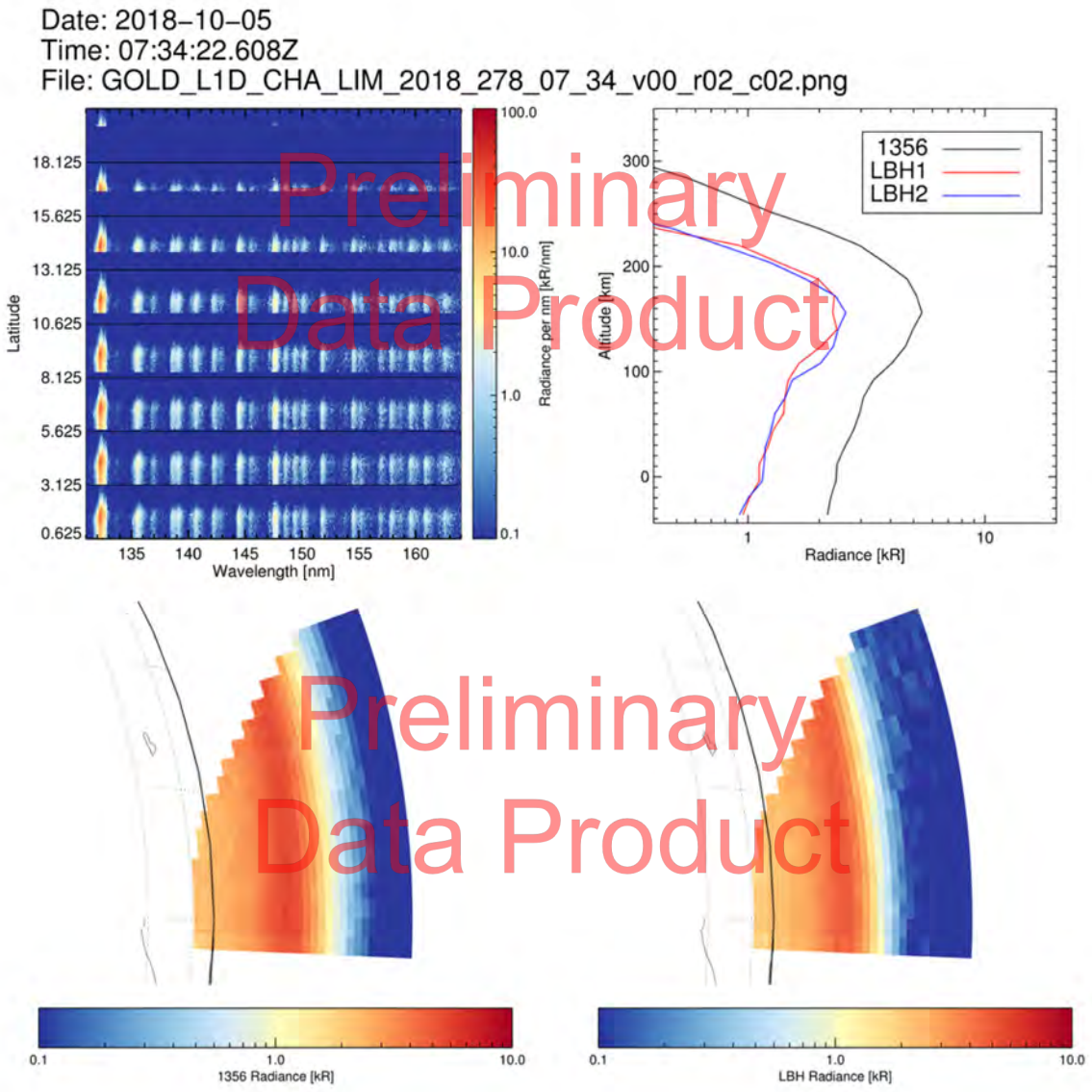
15 minute scan/hemisphere

GOLD DATA PRODUCTS

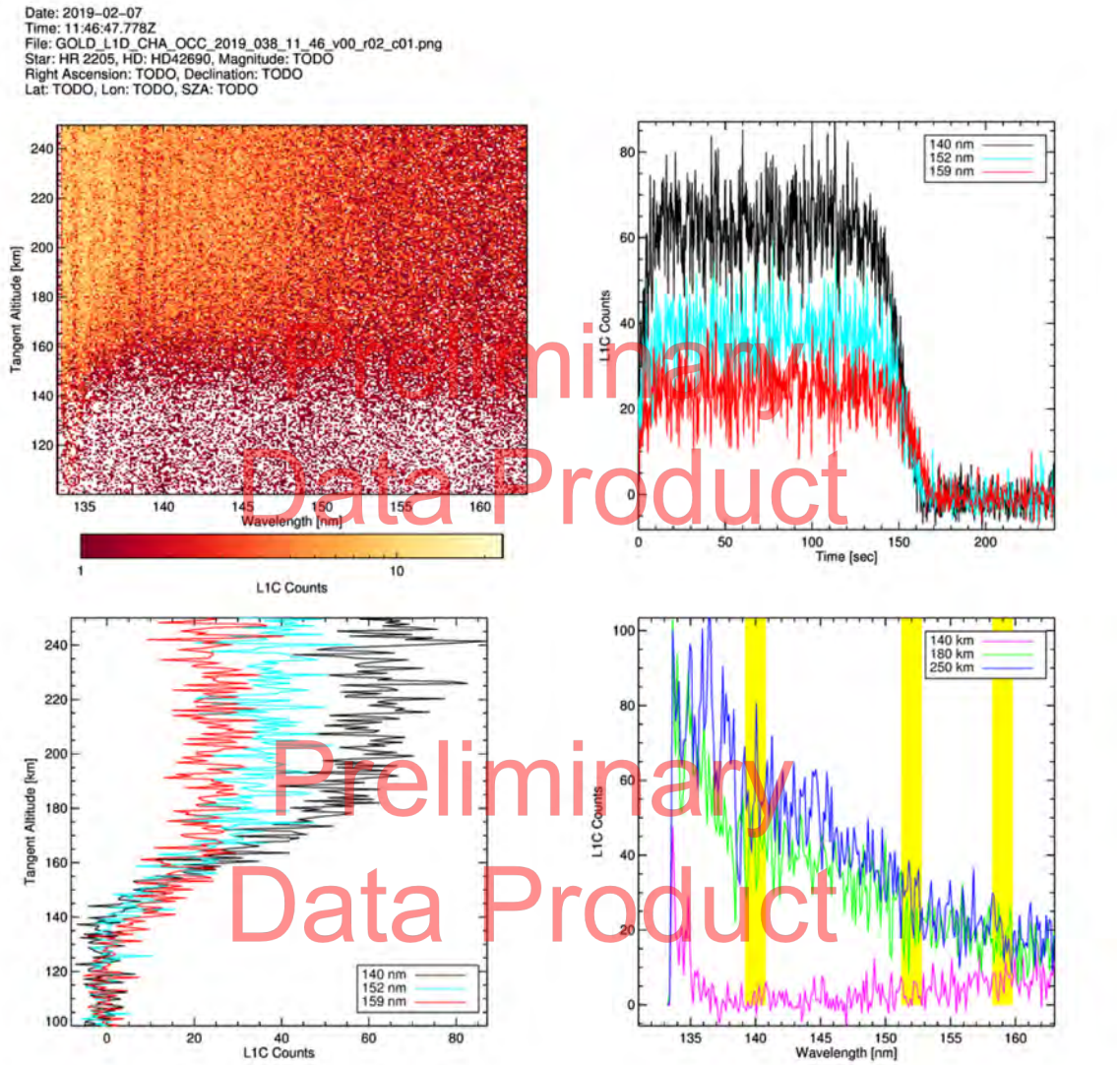
Level 1D Disk Scan



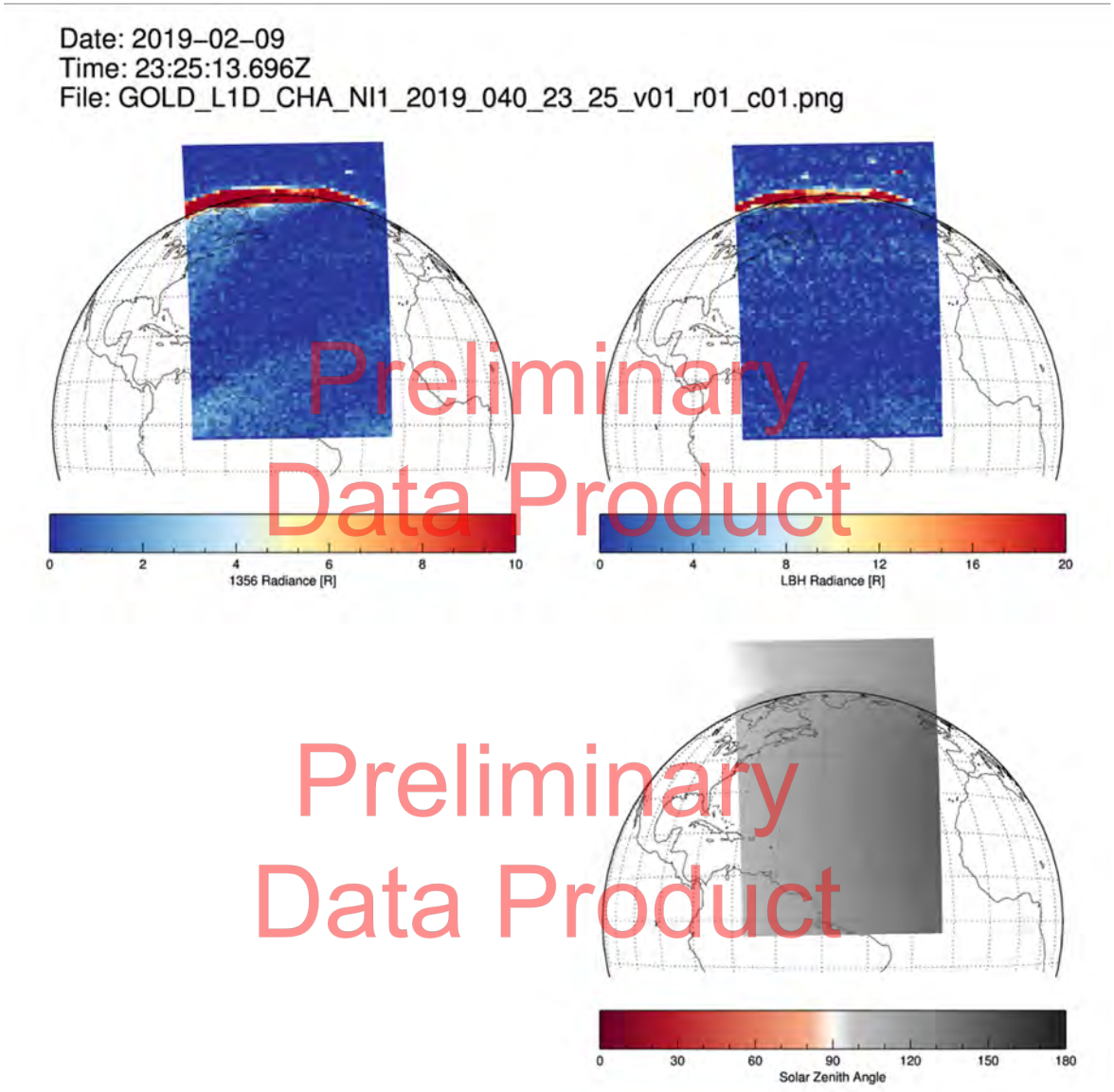
Level 1D Limb Scan



Level 1D Occultation



Level 1D Night Scan



Additional Information

- GOLD web site http://gold.cs.ucf.edu

- Initial science data product releases
  - Level 1 C/D data products will be publicly available by early March
  - Level 2 data products are planned to be publicly available by April