Global-scale Observations of the Limb and Disk (GOLD) Mission – Ultraviolet Imaging of Earth’s Space Environment from Geostationary Orbit

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Scientific Motivation

• GOLD represents the next logical step in Ionosphere-Thermosphere studies
  - Decades of research using observations from low earth orbiting (LEO) spacecraft and ground-based facilities
  - Can not separate daily spatial - temporal variability
  - Enabled the characterization of the I-T system ‘climate’

• GOLD images the I-T system from geostationary orbit (GEO)
  - NASA Explorers Mission of Opportunity
  - Near-hemispherical measurements of composition (O/N_2) and temperature with 1-hour cadence
  - Enables the first characterization of the I-T system ‘weather’
Forcing of the Thermosphere-Ionosphere

Four Scientific Questions Frame the Mission

Forcing from Above

Science Question 1 (Q1). How do geomagnetic storms alter the temperature and composition structure of the thermosphere?

Q2. What is the global-scale response of the thermosphere to solar extreme-ultraviolet variability?

Q3. How significant are the effects of atmospheric waves and tides propagating from below on thermospheric temperature structure?

Q4. How does the nighttime equatorial ionosphere influence the formation and evolution of equatorial plasma density irregularities?

Forcing from Below
GOLD Mission Overview

- **Host Mission**
  - SES-14, in geostationary orbit at 47.5° west (over mouth of the Amazon River)

- **GOLD Instrument**
  - Two identical, independent imaging spectrographs
  - Each observes disk and limb at 132-162 nm

- **Science Data**
  - Earth’s disk
    - Daytime: images of O/N_2_ (density ratio), and temperature
    - Nighttime: images of peak density in ionosphere
  - Earth’s limb (edge of Earth)
    - O_2_ densities and temperature at top of thermosphere
GOLD Mission Imager

- Imaging Spectrograph: Two independent, identical channels imaging the limb and disk, and a single processor packaged in one housing
- Wavelength range: 132 – 162 nm
- Detectors: Microchannel plate, 2-D crossed delay line anode

**Resources Summary**

<table>
<thead>
<tr>
<th>Resource</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>37.0 kg (measured)</td>
</tr>
<tr>
<td>Power</td>
<td>60.4 W (CBE, AVG)</td>
</tr>
<tr>
<td>Data</td>
<td>6 Mbits/second</td>
</tr>
</tbody>
</table>
- Simulated GOLD image of oxygen (135.6 nm) emissions
- Simultaneously images $N_2$ emissions on dayside
- Emissions provide key data for thermosphere and ionosphere
Entrance slit of one (of two) channel is shown as white rectangle.

Slit step rate and position are commandable, can dwell on selected longitude range.
Modeling Tides to Simulate Observations

- **Perturbations in Temperature (T)**
- **Perturbations in O/N₂ Density Ratio**

- T and O/N₂ perturbations at ~160 km due to upward propagating tides
- Typical temperatures are 625K and O/N₂ ratios are 0.5 near 160 km
- Modeled with version 2 of Thermosphere Ionosphere Electrodynamics General Circulation (TIEGCM) model, using to simulate GOLD observations

(K. Greer, Colorado U., LASP)
### Data Products versus Science Requirements

<table>
<thead>
<tr>
<th>Data Product</th>
<th>Notes/Constraints</th>
<th>Requirement</th>
<th>Realized*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Images of Temperature</td>
<td>60 min Cadence 250 x 250 km²</td>
<td>Precision – 55 K</td>
<td>27 K</td>
</tr>
<tr>
<td></td>
<td>Resolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Images of O/N₂ Radiance Ratio</td>
<td>30 min Cadence 250 x 250 km²</td>
<td>Precision – 10 %</td>
<td>6.5 %</td>
</tr>
<tr>
<td></td>
<td>Resolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exospheric Temperature</td>
<td>100 km Vertical Resolution on Limb</td>
<td>Precision – 40 K</td>
<td>22 K</td>
</tr>
<tr>
<td>O₂ Column Density</td>
<td>at 160 km</td>
<td>Precision – 10 %</td>
<td>2 %</td>
</tr>
<tr>
<td></td>
<td>Vertical Resolution – 10 km</td>
<td></td>
<td>5.5 km</td>
</tr>
<tr>
<td>Nmax F2</td>
<td>220 x 220 km² Resolution</td>
<td>Precision – 10 %</td>
<td>5.7 %</td>
</tr>
</tbody>
</table>

*Realized values from retrievals using simulated data
GOLD Status

• Launched on SES-14 - Jan 25, 2018
  - Ariane 5 rocket from French Guiana
• Transfer to GEO in progress
  - Instrument commissioning scheduled for Sep 2018
• Operations begin October 2018

GOLD Launch (Jan 25th, 2018)
Science Data Downlink

- Geostationary orbit, satellite stays over same location
- Each event that occurs in the detectors is sent to the ground
- Data transmitted to GOLD ground station in real-time (24/7)
- Data is only stored on the ground
Ground segment architecture enables near real-time imaging

**SES Satellite Control Center (SCC)**
- Prime: Brazil, Backup/eng: Lux.
- S/C Ops & Instrument Cmd

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

**LASP Science Operations Center (SOC)**
- Boulder, CO
- Instrument monitor, ops, plan, command, 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
Major milestones for Phase E

• + 0 months - beginning of Phase E on October 10, at completion of commissioning
• + 3 months - data validation completed
• + 3 months - first data release to public
  - GOLD web site http://gold.cs.ucf.edu
• + 6 months – first data delivery to SPDF
GOLD Mission Summary

- GOLD will image space environment response to forcing from above and below
- Simultaneous disk images of thermospheric composition and temperature
- Can separate changes in time from changes in location
- Provides context for ground-based and LEO observations
- Now transferring to geostationary orbit
- Two year mission projected to begin 10 October 2018

More details in the poster session

- X4.272: GOLD Science Implementation
Thank You