Global-scale Observations of Limb and Disk (GOLD): Overview of O/N_2 and Q_{EUV} Science Data Products

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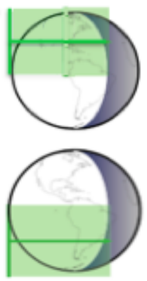
Overview

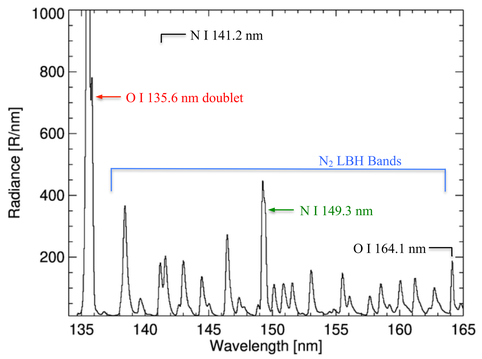
The Global-scale Observations of the Limb and Disk (GOLD) mission launched an imaging spectrograph on 25 January 2018 as a hosted payload on the SES-14 commercial satellite. Science operations began in the Fall of 2018. From its vantage point in geostationary orbit, GOLD images the Earth in the far-ultraviolet from 132 to 162 nm. The instrument consists of two independent optical channels, allowing for a temporal measurement cadence of at least 30 minutes. Data from the GOLD mission provide a new opportunity to interpret composition in the thermosphere. In this presentation we report on GOLD Level 2 data products O/N_2 (ratio of daytime O and N_2 column densities) and Q_{EUV} (integrated solar EUV irradiance 1 - 45 nm), describe the algorithms from which they have been derived and describe the simulations that were made to test them. We demonstrate that the algorithm produces values of O/N_2 with sufficient fidelity to detect changes in composition associated with variations in incoming solar flux and geomagnetic forcing.

Observations

- Dayside disk imaging scans are performed using both channels (CHA and CHB) using the High Resolution (HR) slit.
- Measurements are made between 03:00 and 21:00 hours satellite local time (SLT). GOLD enters solar safe mode from 21:00 to 03:00 hours SLT each night and does operate.
- Morning scans are performed from 03:00 SLT to 04:00 SLT using the identical configuration as the dayside disk scan, except using the Low Resolution (LR) slit.
- Each channel's scan mirror steps the 10.8˚ tall projection of its spectrometer entrance slit across the sunlit portions of the disk in two swaths, one covering the northern hemisphere and the other covering the southern hemisphere, as shown below.
- Each swath requires 12 minutes to complete including setup (24 minutes for a complete disk map) at a fixed rate of 0.05214˚ per step (nadir ground speed of 32.56 km per step at the sub spacecraft point) for 346 scan mirror positions (17.87˚).
- Dwell time per step: 2 seconds.
- Level 1C pixel size: 125 km x 125 km (at nadir).
- The spectral bandpasses used for O/N_2 and Q_{EUV} are
  - O I 135.6 nm : 133.0 – 137.0 nm
  - N_2 LBH : 137.0 – 155.0 nm
  - N I 149.3 nm atomic feature masked out of the spectrum.
- O/N_2 Requirements
  - 10% precision
  - 30 minute cadence
  - 250 km x 250 km spatial resolution (at nadir)



DAY observation mode



Example dayglow spectrum

References

Kil, H., W. K. Lee, J. Shim, L. J. Paxton, and Y. Zhang (2013), The effect of the 135.6nm emission originated from the ionosphere on the TIMED/GUVI O/N_2 ratio, *JGR Space Physics*, 118

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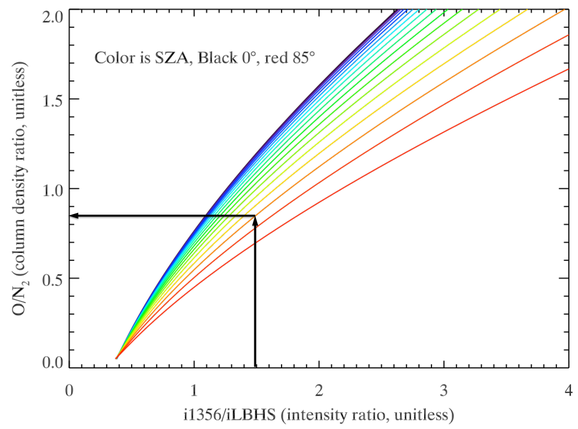
Strickland, D. J., J. L. Lean, R. R. Meier, A. B. Christensen, L. J. Paxton, D. Morrison, J. D. Craven, R. L. Walterscheid, D. L. Judge, and D. McMullin (2004), Solar EUV irradiance variability derived from the terrestrial dayglow, *GRL*, 31

Algorithms

- Lookup tables are used to convert dayglow data to O/N_2 and Q_{EUV}.
- A given table contains nadir O I 135.6 and N_2 LBH radiances derived from the AURIC model [*Strickland et al.,* 1999] as functions of solar zenith angle (SZA) and O/N_2.

O/N_2

- Ratio of O column density above a reference N_2 column density of 10^{17} cm^{-2}.
- Measured ratio of O I 135.6 nm to N_2 LBH & SZA uniquely specifies O/N_2.
- *Strickland et al.* [1995] demonstrated that the derivation of Q_{EUV} and O/N_2 from O I 135.6 nm and N_2 LBH observations is insensitive to the choice of model atmosphere.
- Inputs: 135.6/LBH intensity ratio, uncertainties, SZA, look up table
- Signature of atmospheric dynamics
- GOLD spectral resolution allows for flexibility in choosing best LBH bands



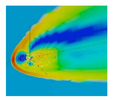
Q_{EUV}

- The integrated solar energy flux shortward of 45 nm.
- This region of the solar spectrum creates the FUV dayglow.
- Some sensitivity to the spectral shape of the assumed solar EUV/XUV irradiances, not to overall magnitude. *Strickland et al.* [2004] demonstrated that doubling solar irradiances below 20 nm produced ~7% change in derived Q_{EUV}.

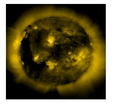
$$Q_{EUV}^{GOLD} = \frac{135.6_{obs}}{135.6_{table}} Q_{EUV}^{ref}$$

GOLD O/N_2 Science Objectives

The GOLD O/N_2 data will be used to address two of the primary GOLD Science Questions



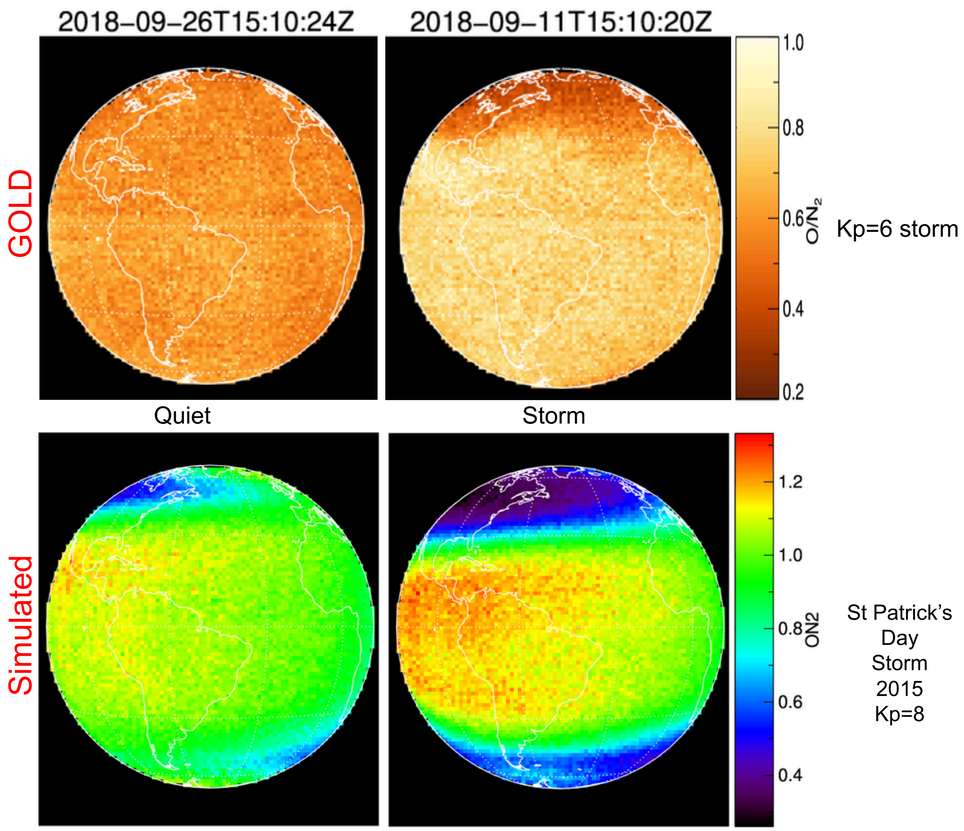
Science Question 1: ***How do geomagnetic storms alter the temperature and composition structure of the thermosphere?***

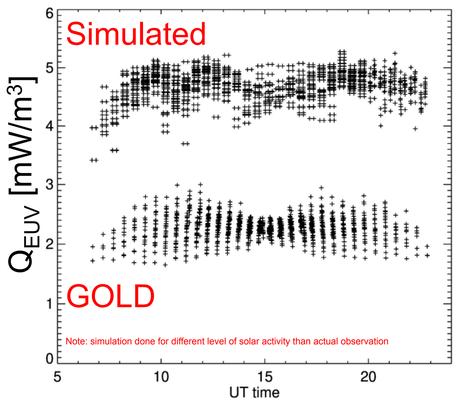


Science Question 2: ***What is the global-scale response of the thermosphere to solar extreme-ultraviolet variability?***

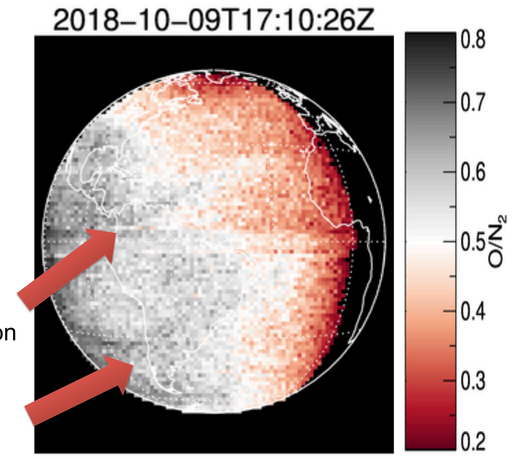
Results

Storm Response - High latitude O/N_2 depletion





Disk images show here are a combination of a North and South hemisphere scan, covering ~30 minutes.



Contamination of O/N_2 due to production of O I 1356 by radiative recombination can be seen in GOLD data. Previously seen in GUVI data by *Kil et al*. [2013].