Simulating Global-scale Observation of Limb and Disk's (GOLD) measurement of the July 2nd, 2019 total solar eclipse's effect on the Ionosphere-Thermosphere system

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Abstract

A total solar eclipse will occur in the southern hemisphere on July 2, 2019 from approximately 17 to 22 UT. It will cross South America where it's effects can be observed from a geostationary orbit by the Global-scale Observation of Limb and Disk (GOLD) instrument. GOLD will observe the changes in OI 135.6 nm and N_2 LBH band emissions, which will be used to derive changes in composition ratios, neutral temperatures on the dayside and peak electron densities on the nightside as a result of the eclipse. Simulations of the eclipse's effects on the Ionosphere-Thermosphere (I-T) system, as seen by the GOLD instrument, have been performed using the Thermospheric General Circulation Model (TIEGCM) and the GLobal airglOW (GLOW) model. Calculation show small but observable differences in the daytime airglow brightnesses (~10 R change) and temperatures (~30K change). The results obtained are being used to deduce the required measurement criteria for GOLD to successfully observe the expected changes. The magnitudes and temporal-spatial development of these changes can be compared with observations. This comparison will provide a test for our understanding of the eclipse's effects on the I-T and their origin.

Background

Moon's shadow moving at supersonic speed blocks solar radiation ➔ localized cooling and reduction in photo-ionization

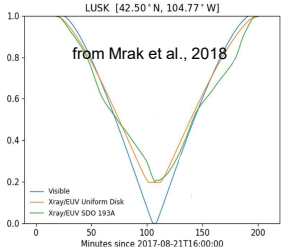


Fig I. Measured attenuation of radiation during the August 21, 2017 eclipse at Lusk, WY. This attenuation leads to rapid cooling and a reduction in photoionization.

Large scale waves propagate away from the eclipse's path causing global scale changes

GOLD observation from a geostationary orbit will provide unique global scale measurement

GOLD: Global-scale Observation of Limb and Disk

GOLD records spectra from ~132-163 nm as a function of slit height from a geostationary orbit above South America

LIMB scans will also be made but this work focuses on day and night disk scans

These measurement of OI 135.6 nm and N_2 LBH provide:

➔ O/N_2 and effective disk Temperature (day)

➔ Electron densities (night)

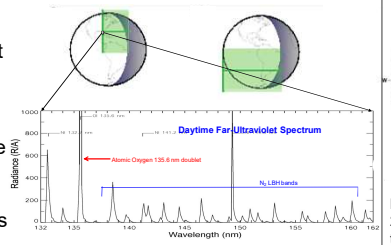


Fig II. Normal day scan mode of the spectrograph

2019 Eclipse and GOLD's view of the Eclipse

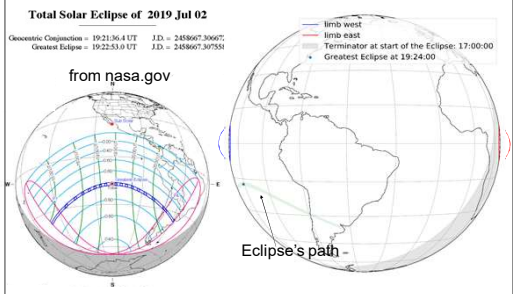


Fig III. Left: Totality (dark blue) and partial eclipse (sky blue) during July 2, 2019 and the times that they occur (green). Right: The eclipse's path of totality (shaded green) as seen by GOLD.

Modeling Eclipse's effect in the I-T

MODELED OUTPUT

TIEGCM runs with an eclipse mask (UV attenuation similar to that shown in Fig I) → **C**

TIEGCM run without the UV mask but otherwise identical to C → **D**

Te, Ne, Tn, etc.

INPUT → GLOW Model ← INPUT: GOLD's line of sight

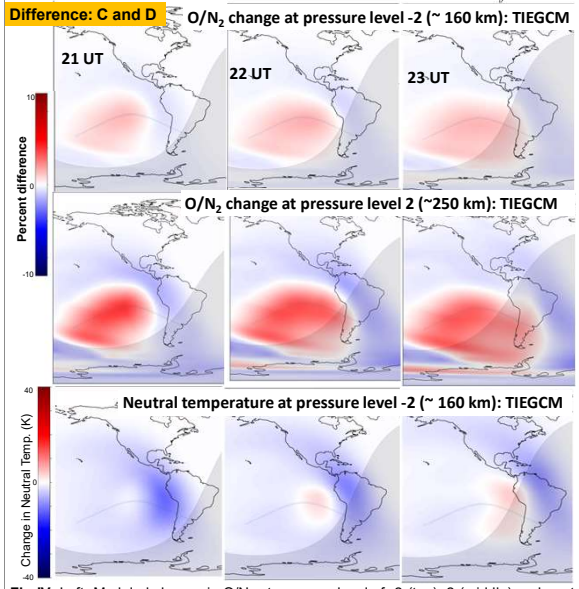
SIMULATED OUTPUT

Airglow brightness estimates with eclipse mapped to GOLD's FOV → **E**

Airglow brightness estimates without eclipse mapped to GOLD's FOV → **F**

Difference: C and D

Difference: E and F



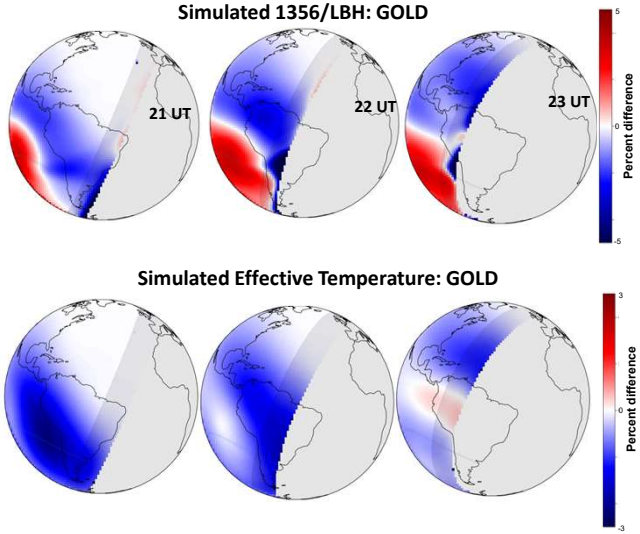


Fig IV. Left: Modeled change in O/N_2 at pressure level of -2 (top), 2 (middle) and neutral temperature at pressure level of -2 (bottom) due to the effect of the July 2, 2019 eclipse as simulated by TGCM at three different times, few hours after the eclipse. Right: Simulated changes in OI 1356/ N_2 LBH ratio (top) and effective temperature as seen by GOLD. Eclipse's path is shown in light gray.

Special campaign mode on July 2

Two channels available (A & B):

A will perform normal full disk scan at 30 minutes cadence

B scans south-western quarter of the disk at 30 minutes cadence until 18:10 LT (22 UT) before switching to normal night scans

At 19:10 LT (23 UT), A starts normal night scans

Summary

Eclipse induced changes in the IT simulated in terms of changes in OI 135.6 nm and N_2 LBH bands as seen by the GOLD instrument

TIE-GCM simulation shows observable change in O/N_2 at pressure level of -2 (daytime GOLD observation)

Changes in O/N_2 at F_2 peak (pressure level 2) may affect the nighttime EIA strength (night-time GOLD observation)

Changes due to the lower atmosphere have an effect but are not included in this study. How much of a difference would it make?

GOLD observation of the July 2, 2019 eclipse will help address these questions

CEDAR, 2019

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