Global-scale Observations of the Limb and Disk (GOLD): Science Implementation

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The GOLD Instrument Measures Temperature and Composition of the I-T System Using Imaging and Occultation Spectroscopy

Abstract

The Global-scale Observations of the Limb and Disk (GOLD) is a NASA mission of opportunity that will image the Earth's thermosphere and ionosphere from geostationary orbit. GOLD will investigate how the thermosphere-ionosphere (T-I) system responds to geomagnetic storms, solar radiation, and upward propagating tides. Launched by an Ariane 5 rocket aboard SES 14, GOLD will be placed into orbit at 47.5˚ West longitude, where it will begin routine operations in the fall of 2018. The mission is framed by four scientific questions: How do geomagnetic storms alter the temperature and composition structure of the thermosphere? What is the global-scale response of the thermosphere to solar extreme-ultraviolet variability? How significant are the effects of atmospheric waves and tides propagating from below on the thermospheric temperature structure? How does the structure of the equatorial ionosphere influence the formation and evolution of equatorial plasma density irregularities? GOLD will address these questions using data from a pair of identical imaging spectrographs that will observe emissions from atomic oxygen and molecular nitrogen in the the far-ultraviolet from 132 to 162 nm. During the day, images of composition and temperature will be made from molecular nitrogen Lyman-Birge-Hopfield (LBH) band and atomic oxygen 135.6 nm emissions. On the limb, exospheric temperature will be obtained from altitude profiles of LBH emission, and molecular oxygen density will be measured using stellar occultations. Electron density will be derived from 135.6 nm emission at night. These are obtained by using internal instrument scan mirrors to image both the disk and limb with a 30-minute cadence. This presentation describes the GOLD mission science implementation including nominal observing scenarios and predicted instrument measurement performance. It also describes the forward modeling approaches used by the GOLD team to validate that the instrument and observing plan will return adequate data to answer the science questions.

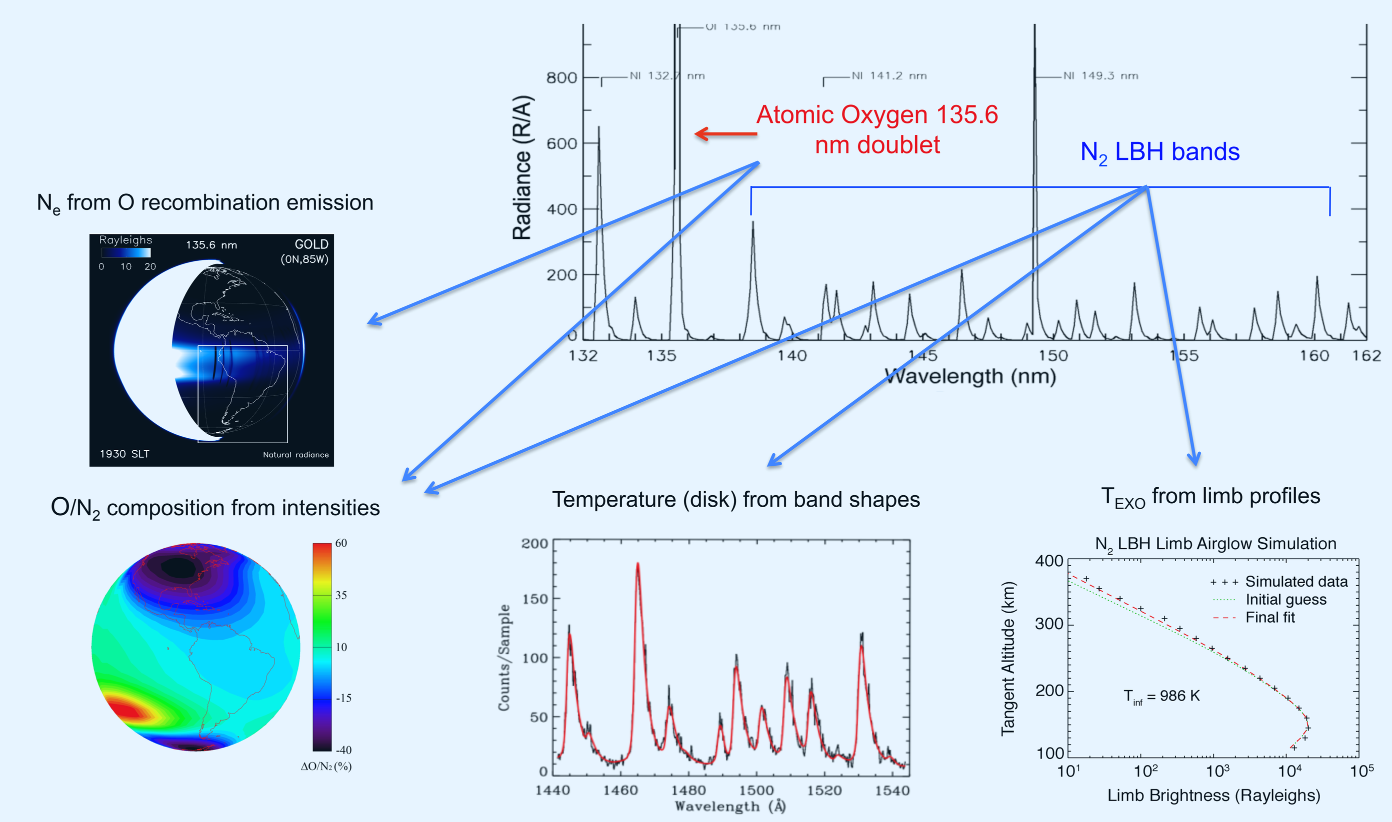
GOLD Mission Science Measurement Requirements

1. Make disk images of atomic oxygen (O) 135.6 nm emissions and molecular nitrogen (N_2) Lyman-Birge-Hopfield (LBH) emissions over a latitude range of ±60˚ and a longitude range of ±70˚ relative to spacecraft nadir.
2. Construct, on the sunlit portion of the disk, images of:
   i. lower thermosphere temperature with a precision of ±55 K with 60 minute cadence and spatial resolution of 250 km × 250 km (at nadir)
   ii. thermosphere column composition (O/N_2 density ratio) with a precision of 10% with 30 minute cadence and spatial resolution of 250 km × 250 km (at nadir).
3. Construct, on the nighttime portion of the disk, images of Nmax F2, at the peak of the equatorial arcs, with a precision of 10% and a latitude resolution of 2˚.
4. Track ionospheric bubbles (depletions) within a single equatorial arc with a precision of 20% in brightness and a spatial resolution (at nadir) of 100 km in the longitudinal direction.
5. Measure near-equatorial limb profiles of the N_2 LBH emissions.
6. Measure exospheric temperature (near-equatorial) with a precision of ±40 K in the daytime.
7. Measure O_2 line-of-sight column densities above 150 km with a precision of ±10% and a vertical resolution of 10 km in the nighttime and daytime by stellar occultation.
8. Perform all of the above from geostationary orbit for two years.

Measurements

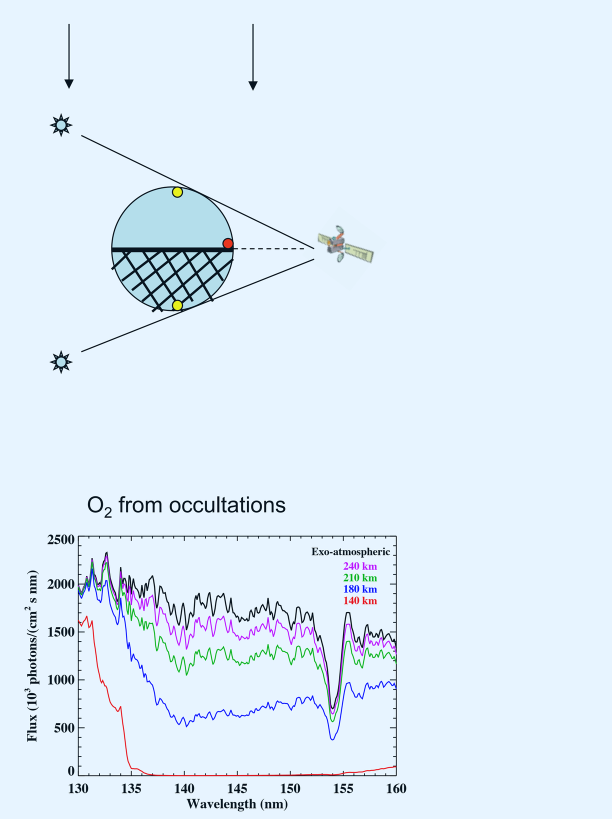
Emission Spectroscopy: O/N_2, T_{Disk}, T_{Exo}, O

1. Constructs spatial-spectral image cubes using whiskbroom imaging
2. Full disk image + limb profile on 30 minute cadence



Occultation Spectroscopy: O_2

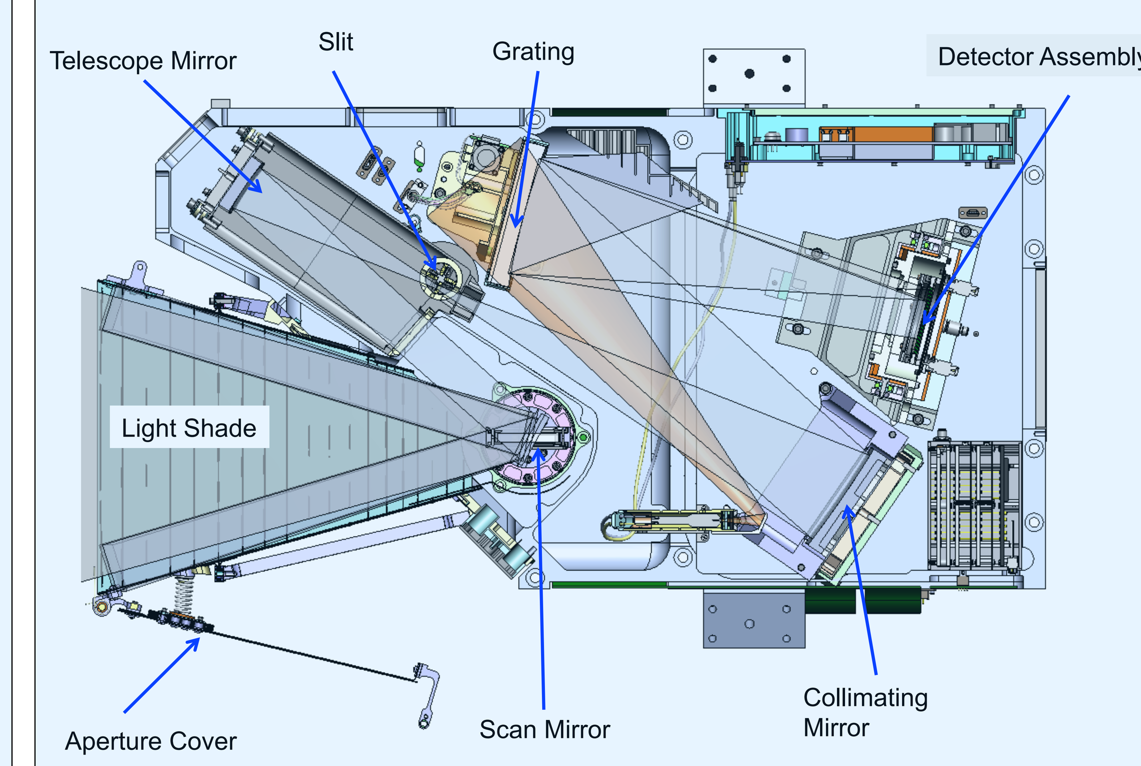
1. Star drifts through a 1˚ wide occultation slit Limb stare
2. O_2 line-of-sight column densities 150 – 240 km



Instrument

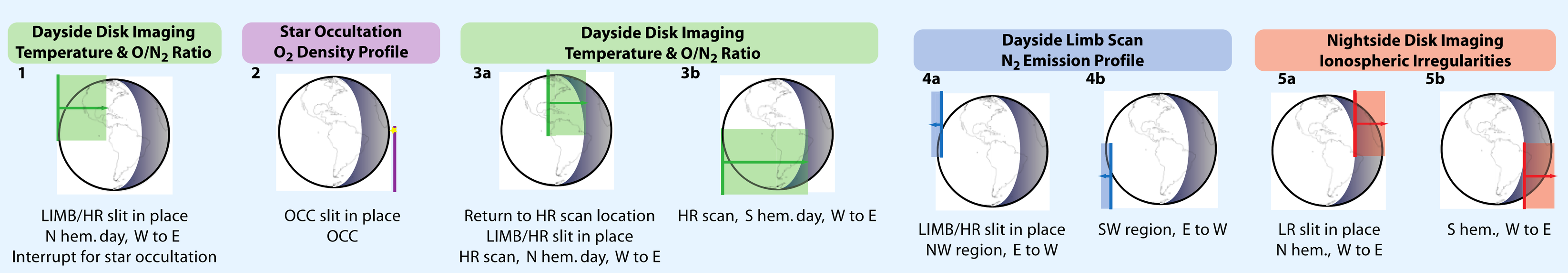
Pair of Identical Telescope-Spectrometers

1. 132 – 162 nm coverage
2. 0.2 – 1 nm spectral resolution
3. Scan mirror for independent fields of view
4. Mass, Power, Data Rate: 37kg, 60.4W, 6Mbit/sec



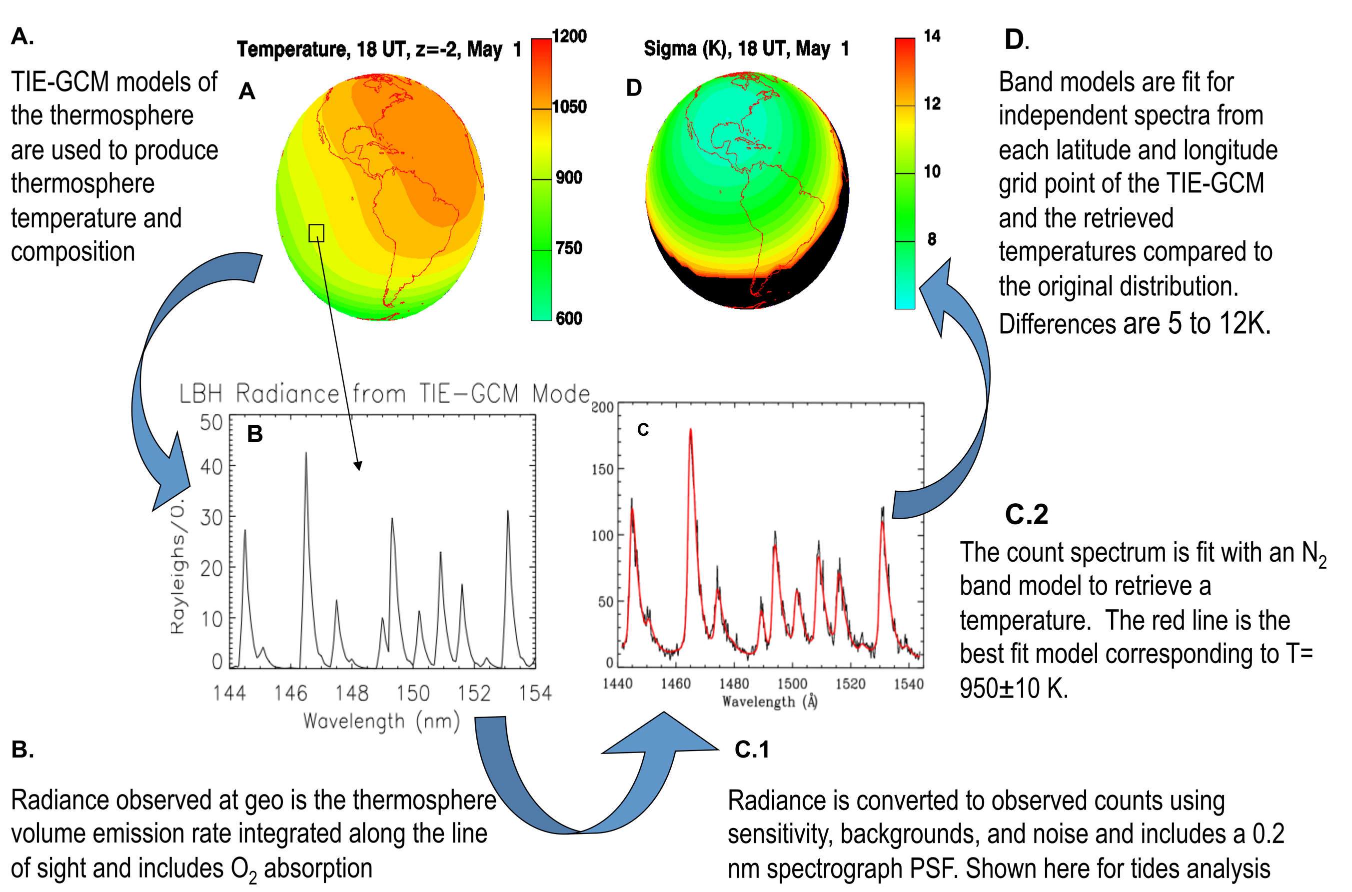
Observing Modes

Image cubes are constructed using whisk-broom scanning



Forward Modeling Simulations

Approach



A. TIE-GCM models of the thermosphere are used to produce thermosphere temperature and composition

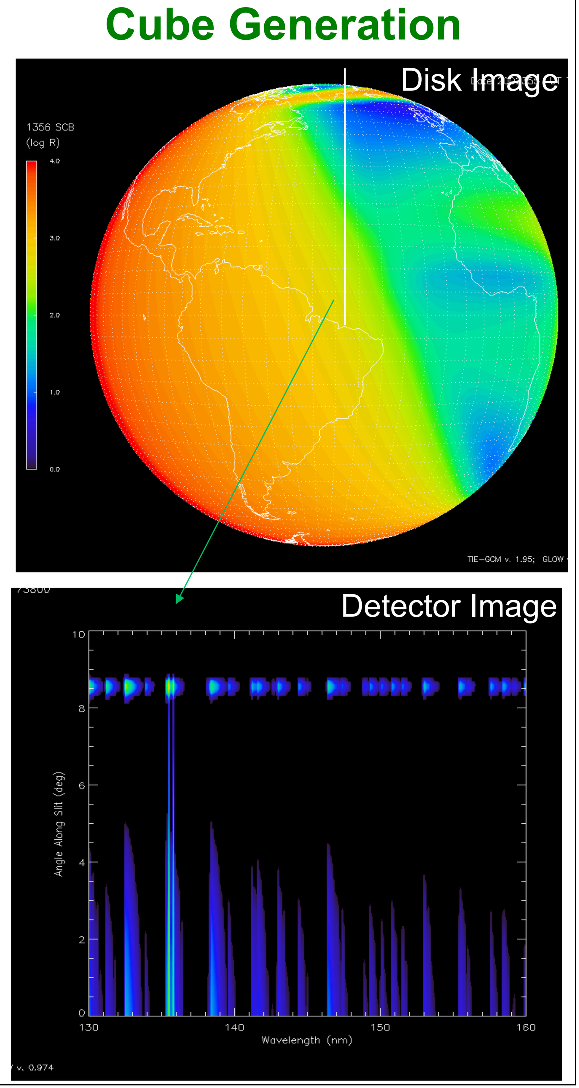
B. Radiance observed at geo is the thermosphere volume emission rate integrated along the line of sight and includes O_2 absorption

C.1 Radiance is converted to observed counts using sensitivity, backgrounds, and noise and includes a 0.2 nm spectrograph PSF. Shown here for tides analysis

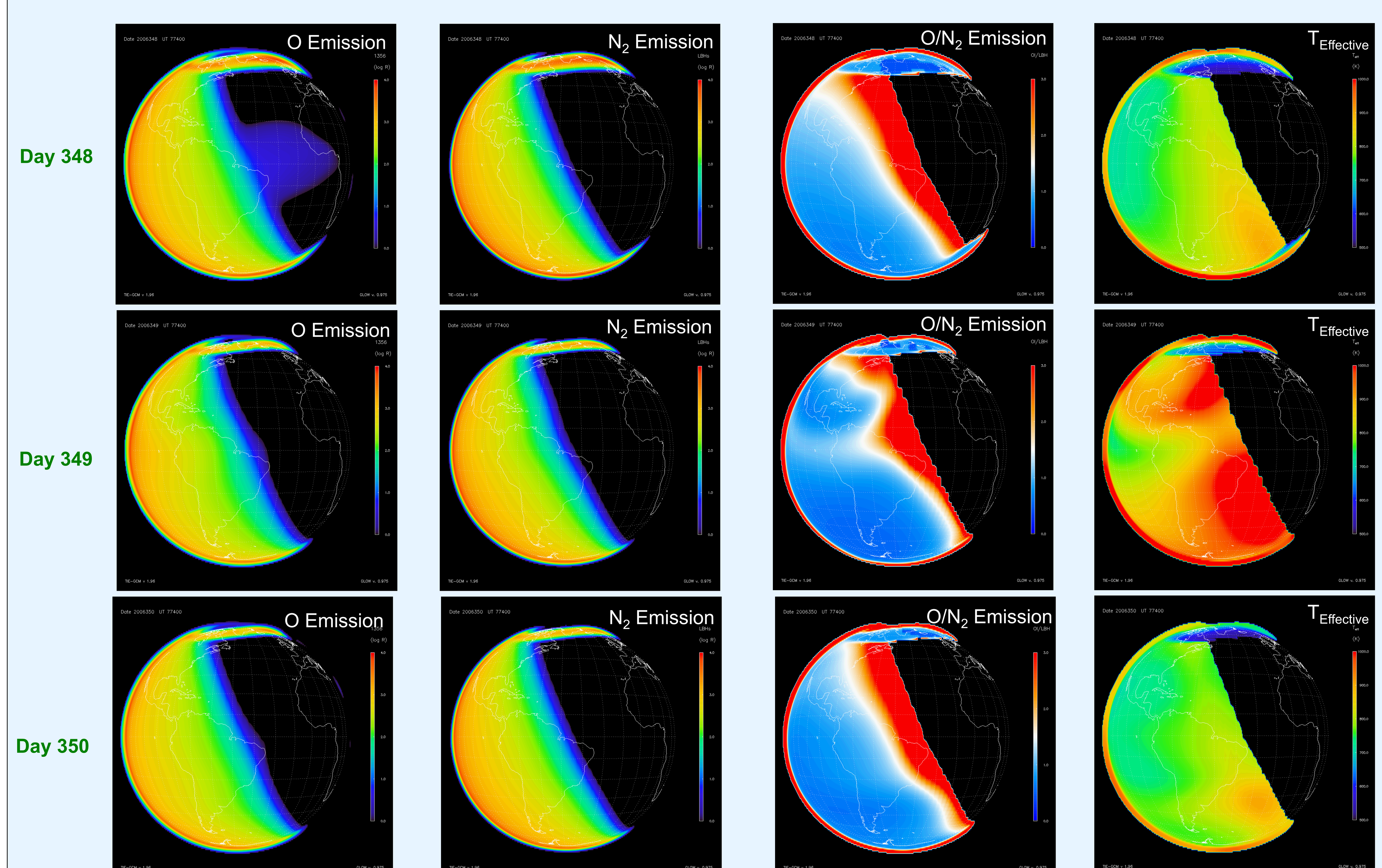
C.2 The count spectrum is fit with an N_2 band model to retrieve a temperature. The red line is the best fit model corresponding to T= 950±10 K.

D. Band models are fit for independent spectra from each latitude and longitude grid point of the TIE-GCM and the retrieved temperatures compared to the original distribution. Differences are 5 to 12K.

Cube Generation

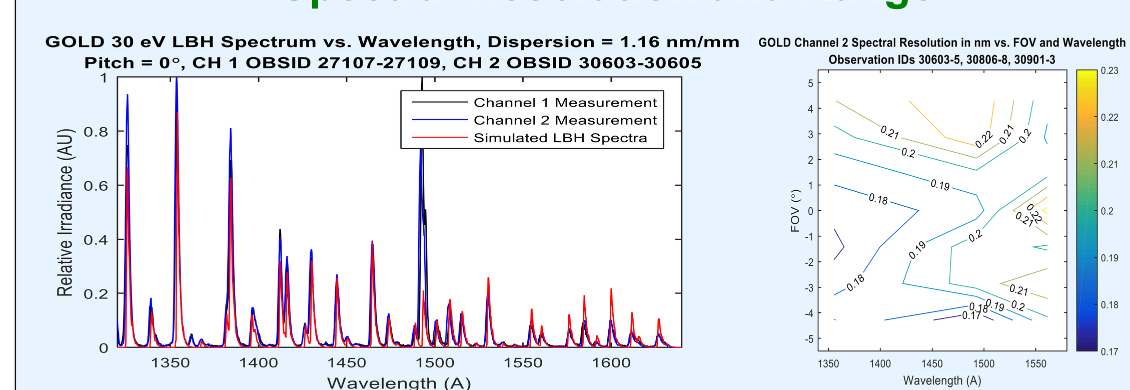


Simulated GOLD Images of O-135.6 and N2-LBH Emissions, O/N2 Emission Ratio and Effective Temperature for 3 Successive Days Centered on the AGU 2006 Geomagnetic Storm

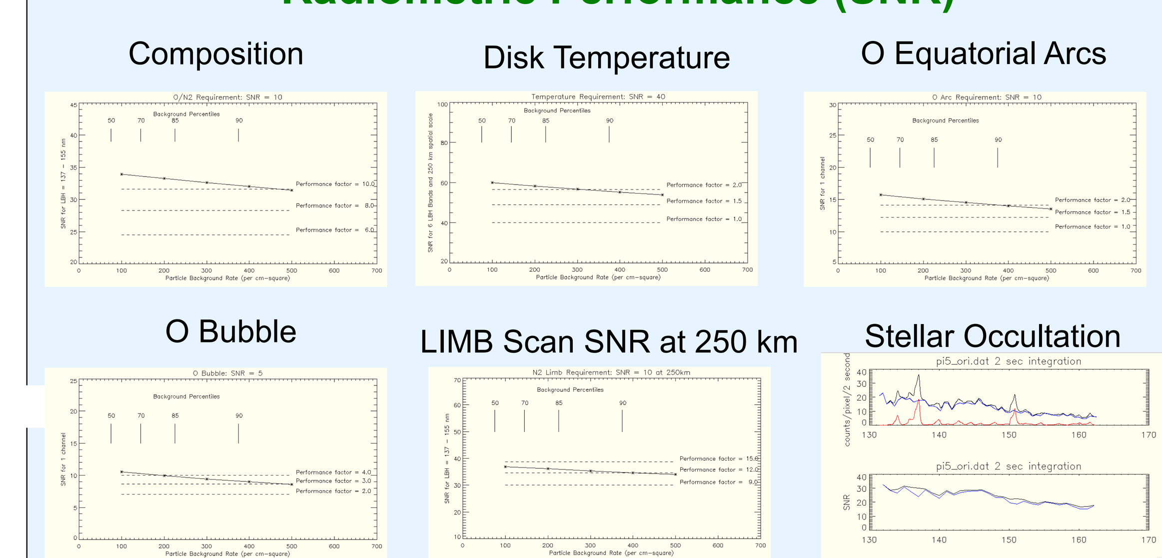


GOLD Exceeds Its Science Measurement Requirements

Spectral Resolution and Range



Radiometric Performance (SNR)



Radiometric Calculation Assumptions

- GUVI measurements of O and N_2 radiances at Solar min
- Average 20kR and 10kR H – 121.6nm and O – 130.4nm radiances
- Geostationary energetic particle fluxes calculated using AE-8 Model