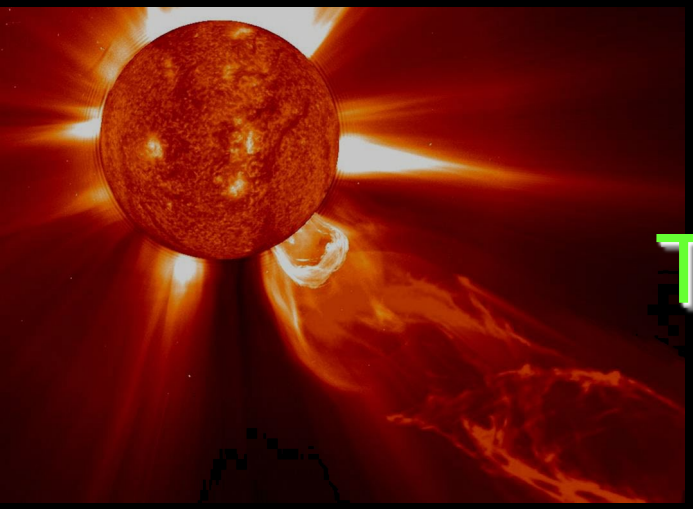

Thermospheric Composition and Solar EUV Irradiance Trends Retrieved from FUV Dayglow Observations

Robert R. Meier

George Mason University

rmeier@gmu.edu

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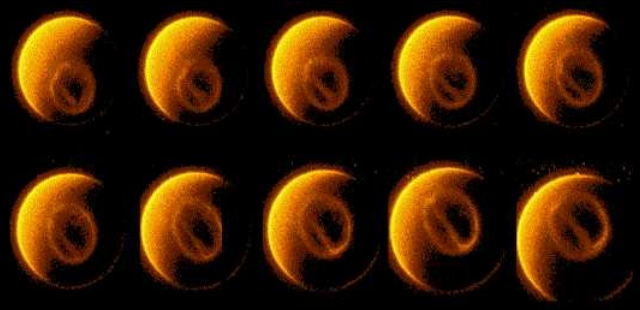
Topics

- FUV remote sensing of thermosphere
- Composition retrieval from dayglow
- Solar EUV irradiance retrieval
- O/N_2 composition measurements
- Solar EUV measurements

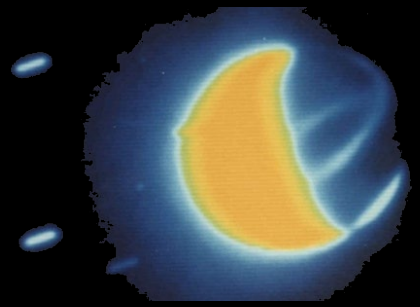
Selected FUV Earth Imaging Missions

FUV camera on Moon



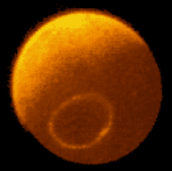
Dynamics Explorer, 1981

Courtesy John Craven



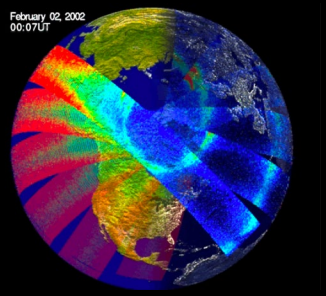
Apollo 16 FUV
1972

Courtesy George Carruthers

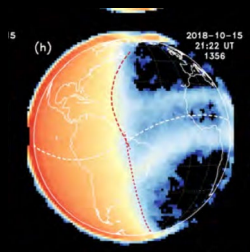


POLAR FUV
1996

IMAGE FUV
2000



GUVI
2002



GOLD
2018

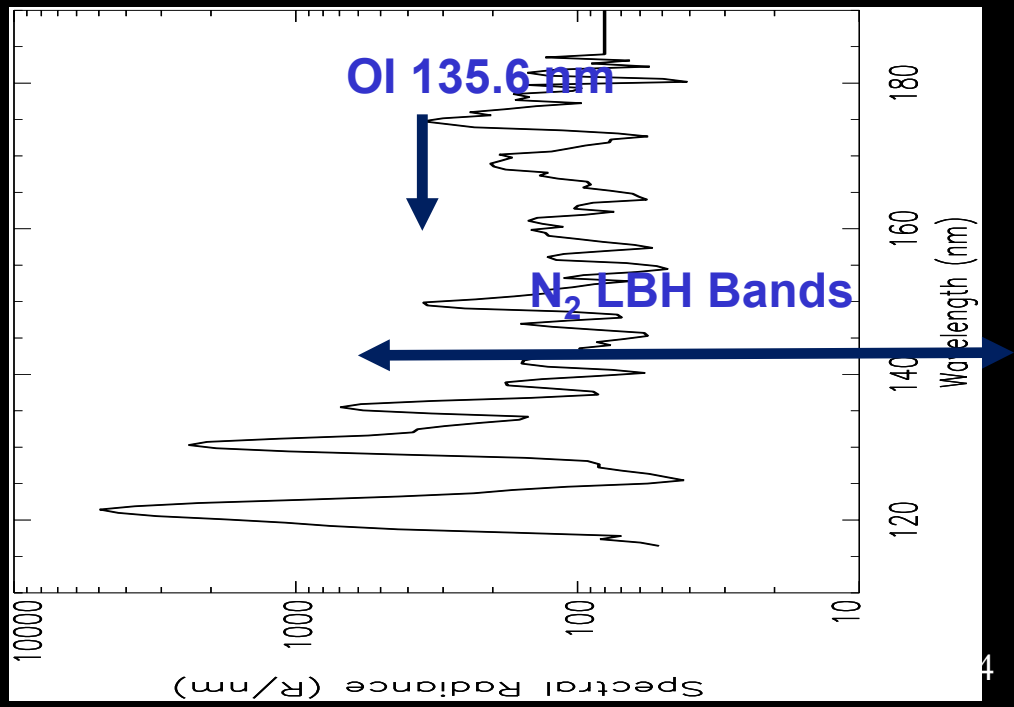
Coming Soon

ICON
2019

Principal FUV Remote Sensing Emissions
(Currently in use for thermosphere)

- OI 135.6 nm production: $e^* + O(^3P) \rightarrow e + O(^5S)$
- N_2 LBH production: $e^* + N_2(X^1\Sigma^+_g) \rightarrow e + N_2(a^1\Pi_g)$

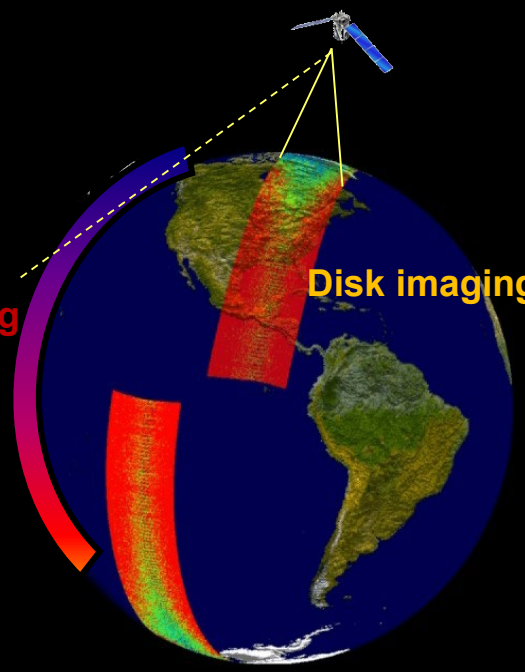
GUVI FUV Dayglow Spectrum, 2002

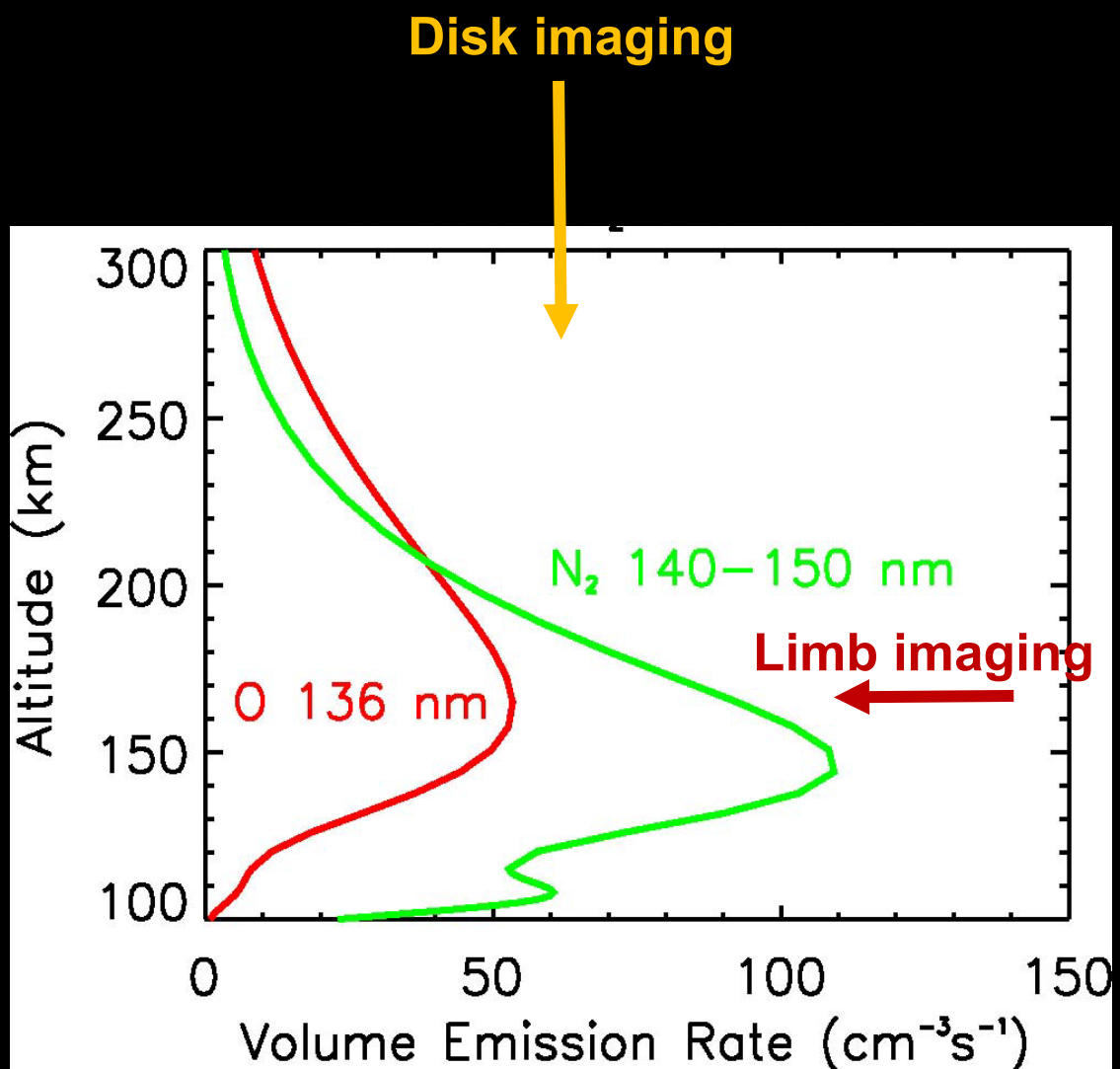


Why O and N_2?

- Main constituents of upper thermosphere
- O/N_2 highly responsive to
  - composition
  - geomagnetic storm dynamics
- electron densities are proportional to O/N_2

What do O and N_2 FUV Emissions Measure?





<u>Perennial Problem:</u>

Disk measurements have no altitude information

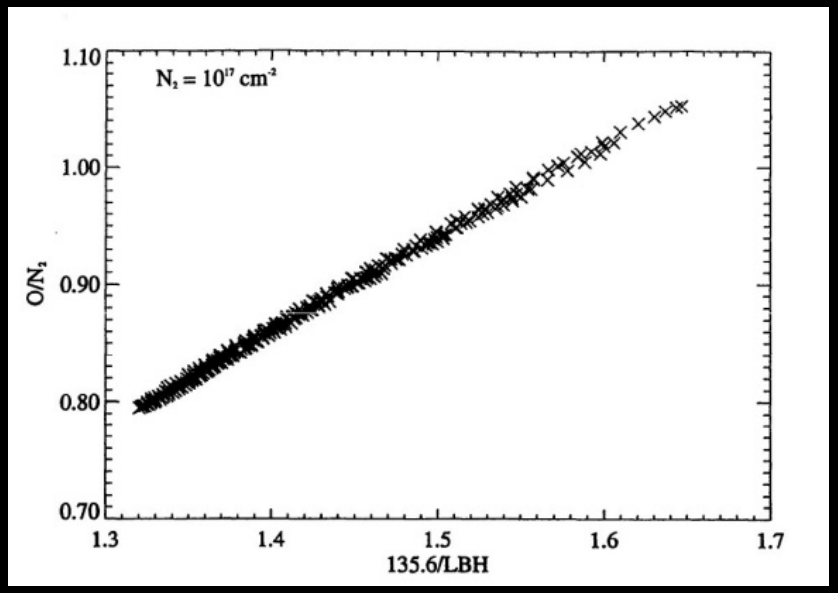
Can We obtain Quantitative Information from Disk Data?

- Early FUV imaging used for context
- Strickland et al. [1995] breakthrough
  - Obtain <u>column</u> O/N_2 composition ratio from 135.6 nm / LBH intensity ratio
    - Can now relate observations and models
  - Infer integrated solar EUV irradiance
    - How much solar EUV is required to produce dayglow?

Column O/N_2 Definition

Intensity ratio ∝ O/N_2

$$\frac{I_{135.6}}{I_{LBH}} \propto \frac{\int_{z_o}^{\infty} n_O(z')dz'}{\int_{z_o}^{\infty} n_{N2}(z')dz'}$$



Column Ratio

Emission Ratio

Works best when

$$\int_{z_o}^{\infty} n_{N2}(z')dz' = 10^{17} cm^{-2}$$

Create parameterized table lookup: $\frac{O}{N_2}$ vs $\frac{135.6}{LBH}$

Define Solar EUV Irradiance Parameter

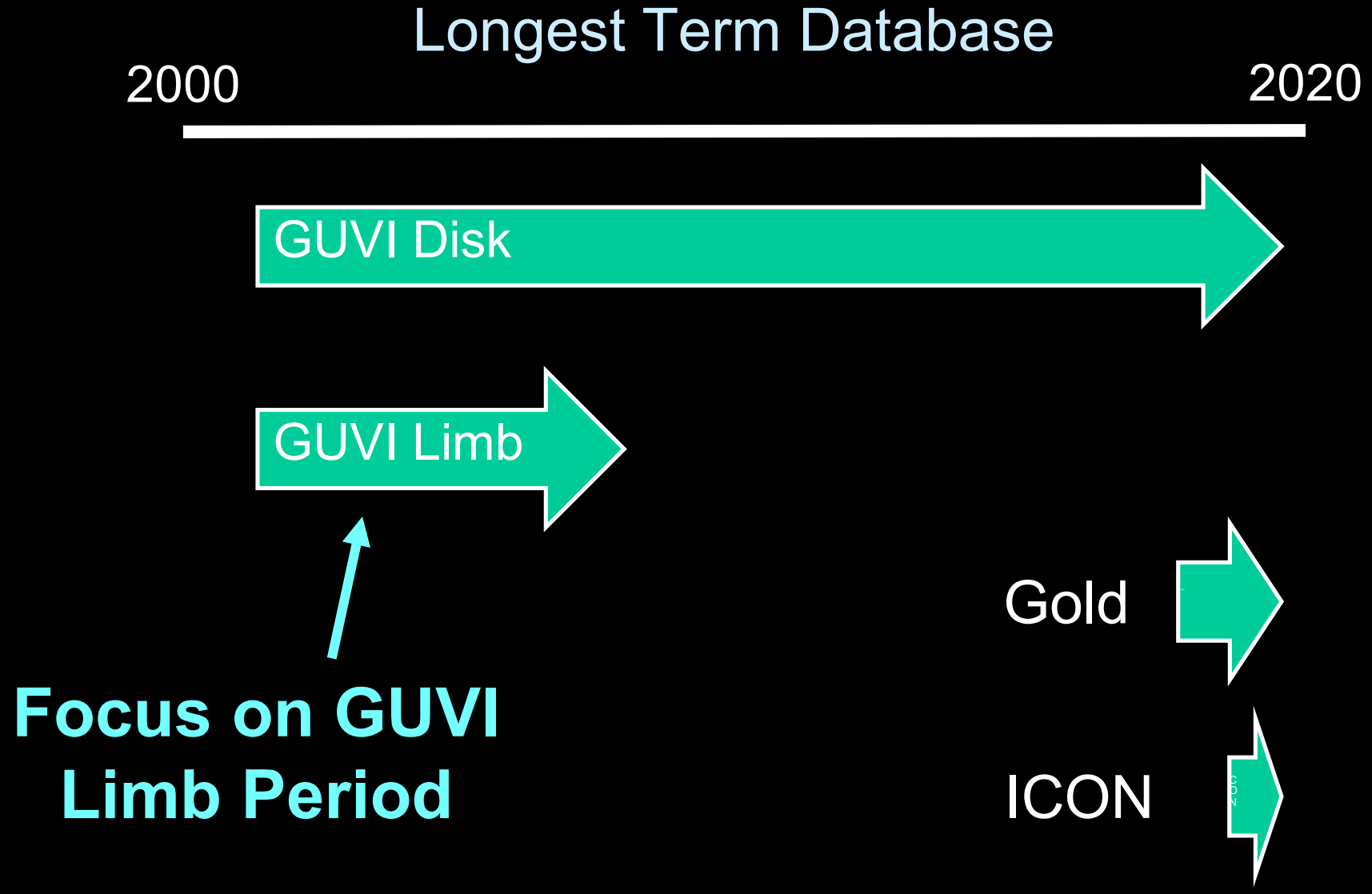
$$Q_{euv} = \int_0^{45} F(\lambda) d\lambda \quad (mW\ m^{-2})$$

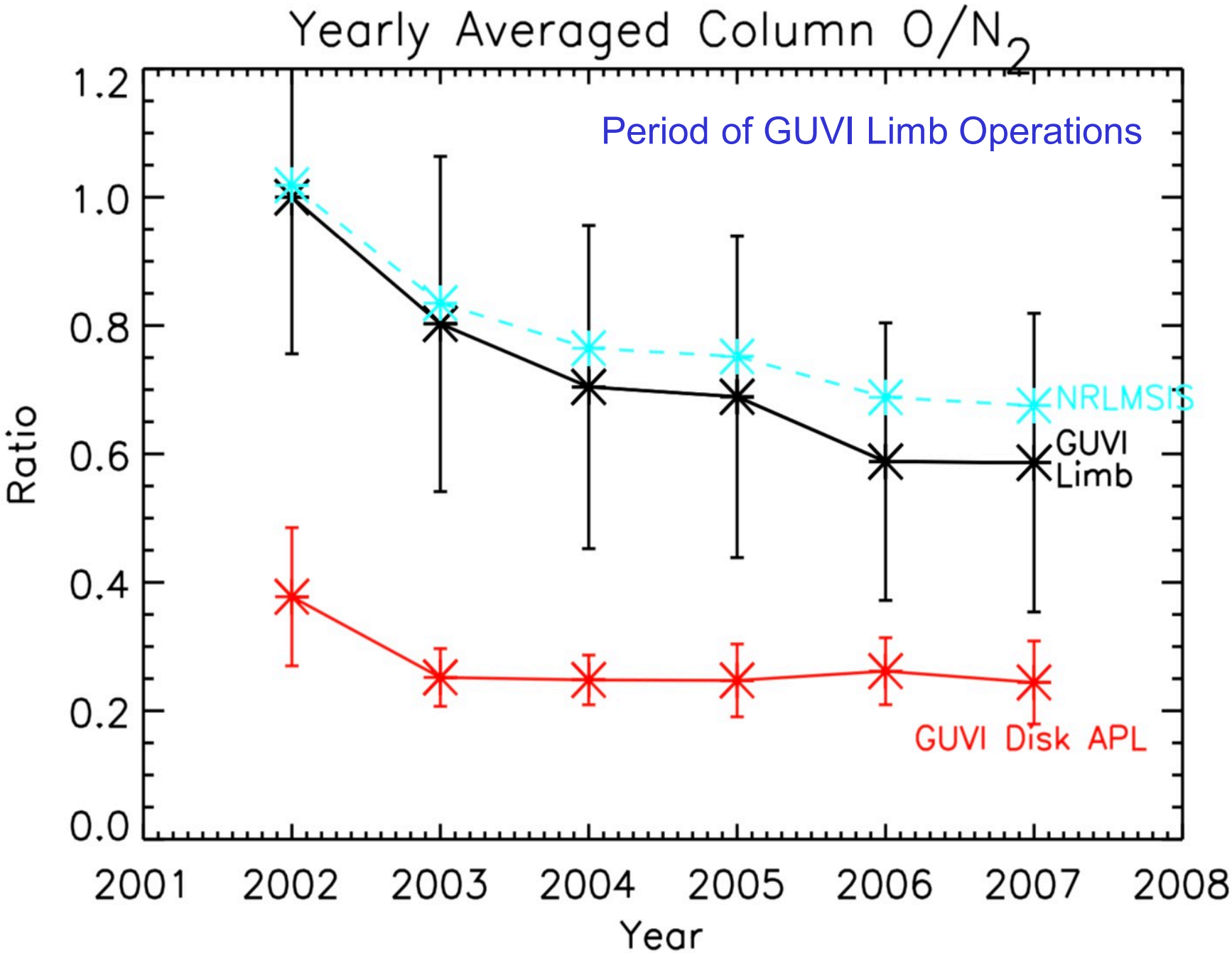
Prescription:

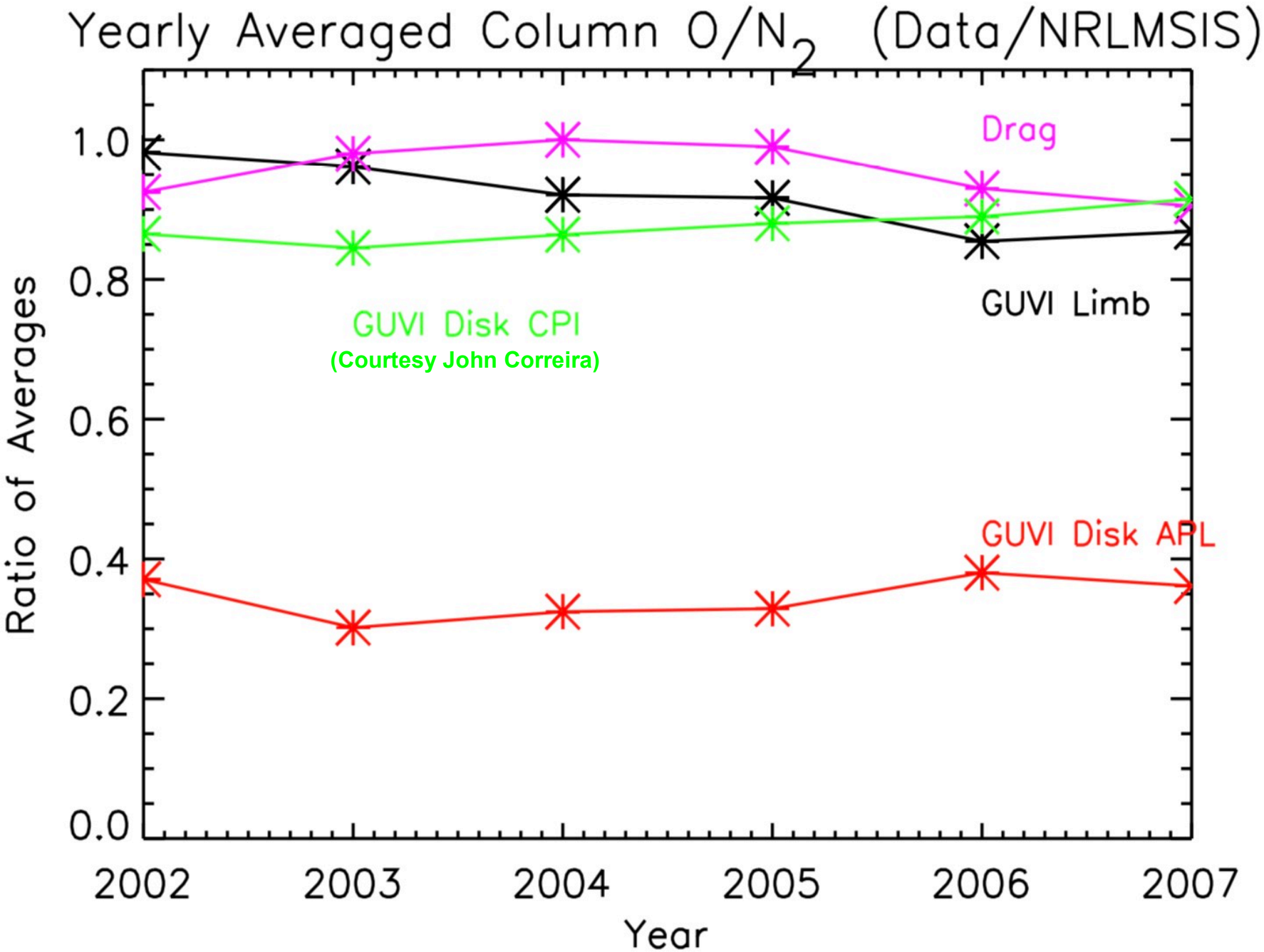
1. Measure OI 135.6 nm & N_2 LBH on disk
2. Extract column O/N_2 from $\boldsymbol{I}_{135.6}/\boldsymbol{I}_{LBH}$
   - Gives partitioning between135.6 nm and LBH
3. Obtain Q_{euv} from $\boldsymbol{I}_{135.6}$ (or $\boldsymbol{I}_{LBH}$)
   - Magnitude of solar EUV needed to match intensity

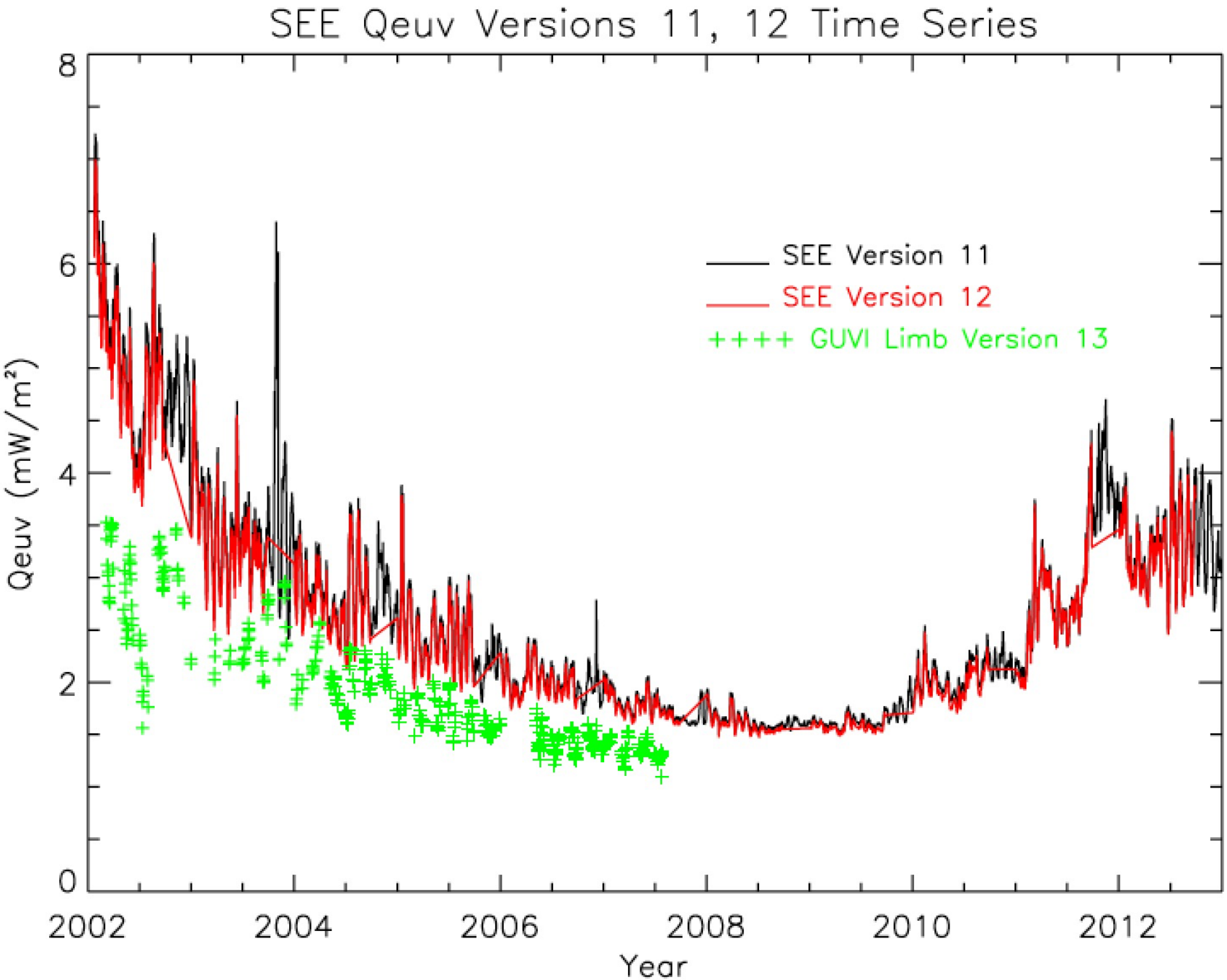
Results from Global Ultraviolet Imager (GUVI)

Longest Term Database

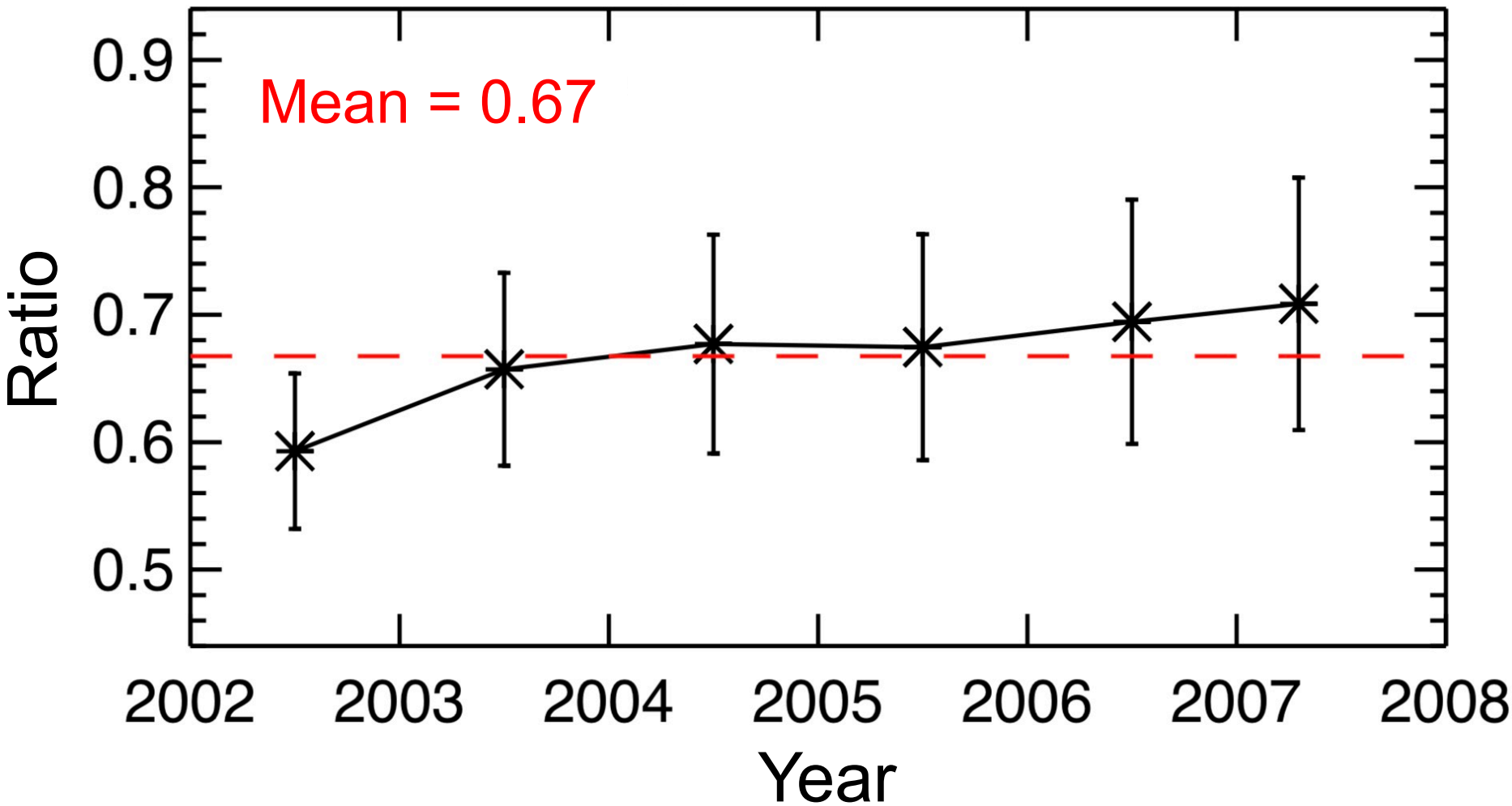



Yearly Averaged Column O/N2
Period of GUVI Limb Operations
NRLMSIS
GUVI Limb
GUVI Disk APL
Ratio
Year
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2001
2002
2003
2004
2005
2006
2007
2008


Yearly Averaged Column O/N2 (Data/NRLMSIS)
Drag
GUVI Limb
GUVI Disk CPI
(Courtesy John Correira)
GUVI Disk APL
Ratio of Averages
1.0
0.8
0.6
0.4
0.2
0.0
2002
2003
2004
2005
2006
2007
Year


SEE Qeuv Versions 11, 12 Time Series
SEE Version 11
SEE Version 12
++++ GUVI Limb Version 13
Qeuv (mW/m²)
Year
0
2
4
6
8
2002
2004
2006
2008
2010
2012

GUVI Q_{euv} / SEE Q_{euv} Ratio



So Where are we Now?

- Physical principles are sound
  - Solar input and atmosphere output must agree
- Column O/N_2 discrepancies
  - 3 separate research groups with 3 models
- Q_{euv} ~ 30% difference between dayglow and direct measurements
  - Wait for GOLD and ICON (+EVE)
- **Way forward: A new disk approach**
  - Does not require synthesized algorithm
  - Guarantees limb and disk consistency