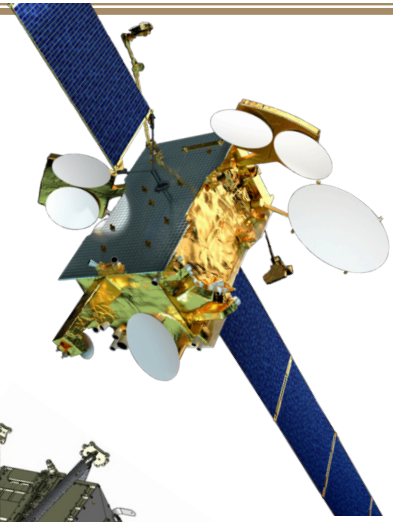
Global-scale Observations of the Limb and Disk (GOLD): Mission of Opportunity

Managing Partners and Resources
PI Team Masters Forum #6

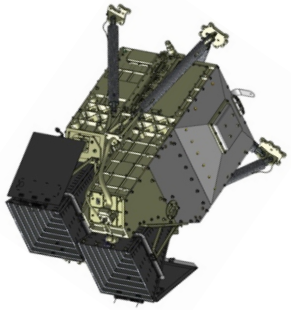
By Richard Eastes
GOLD Mission PI

GOLD Mission Overview

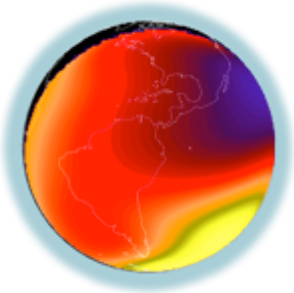
- **Host Mission**
  - Host mission will be SES-14
    - Satellite is a GEO commercial communications satellite at 47.5°W
    - Launch date is Sept. 2017 on SpaceX Falcon 9
  - Owned and operated by SES
- **GOLD Instrument**
  - GOLD payload is an imaging spectrograph being built at LASP
  - Imager observes limb and disk at 132-160 nm
- **Science Data Center at UCF**
  - Produces O/N_2, Tdisk, etc.
  - Data on website, also at NASA Space Physics Data Facility (SPDF)



SES Government Solutions

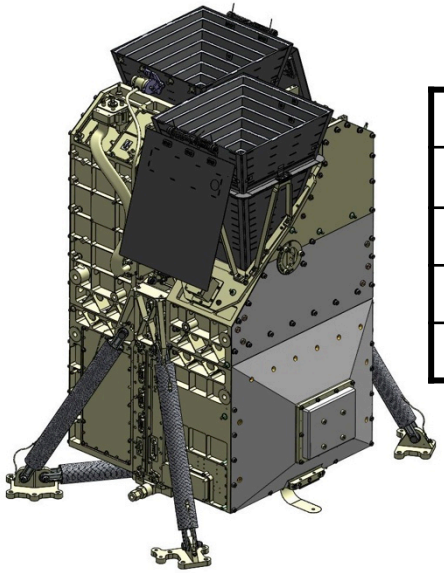


LASP



UCF

GOLD Mission Summary



Instrument Summary	
Mass	36.8 (CBE)
Power	72.4 W (CBE, avg)
Size	51 × 55 × 69 cm^3
Data	6 Mbps

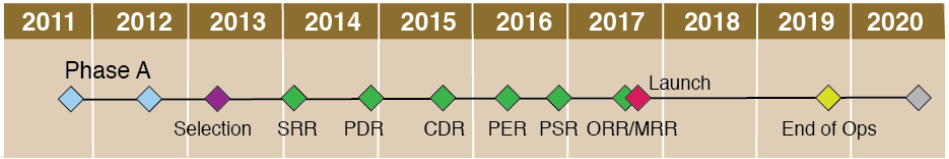
Imaging Spectrograph:

Two independent, identical channels

Wavelength range: 132 – 160 nm

Detectors: Microchannel plate, 2-D crossed delay line anode

Target Launch: 2017



Florida Space Institute (FSI)
University of Central Florida

PI: Richard Eastes

Project Coordinator: Andrey Krywonos

Laboratory for Atmospheric and Space Physics (LASP)
University of Colorado

Deputy PI: William McClintock

Project Manager: Rory Barrett

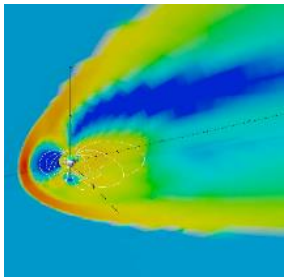
Observations:

- Disk maps of neutral temperature
- Disk maps of O/N_2 density ratio
- Limb scans (for temperature)
- Disk maps of peak electron density
- Stellar occultations

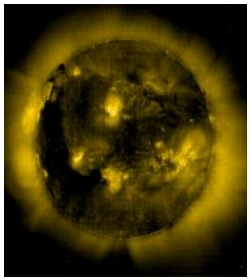
$64M (RY) Mission of Opportunity, 2 year mission

Weather in the Thermosphere-Ionosphere

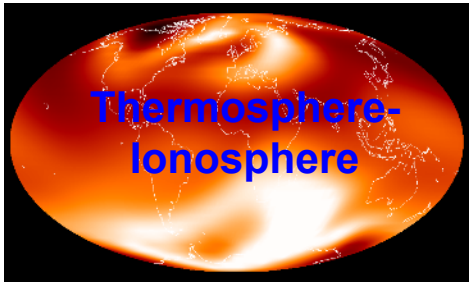
Forcing from Above



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

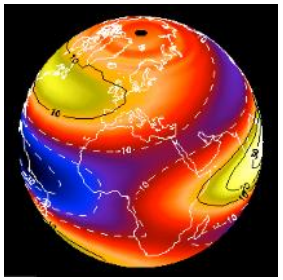


Q2. What is the global-scale response of the thermosphere to solar extreme-ultraviolet variability?



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

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



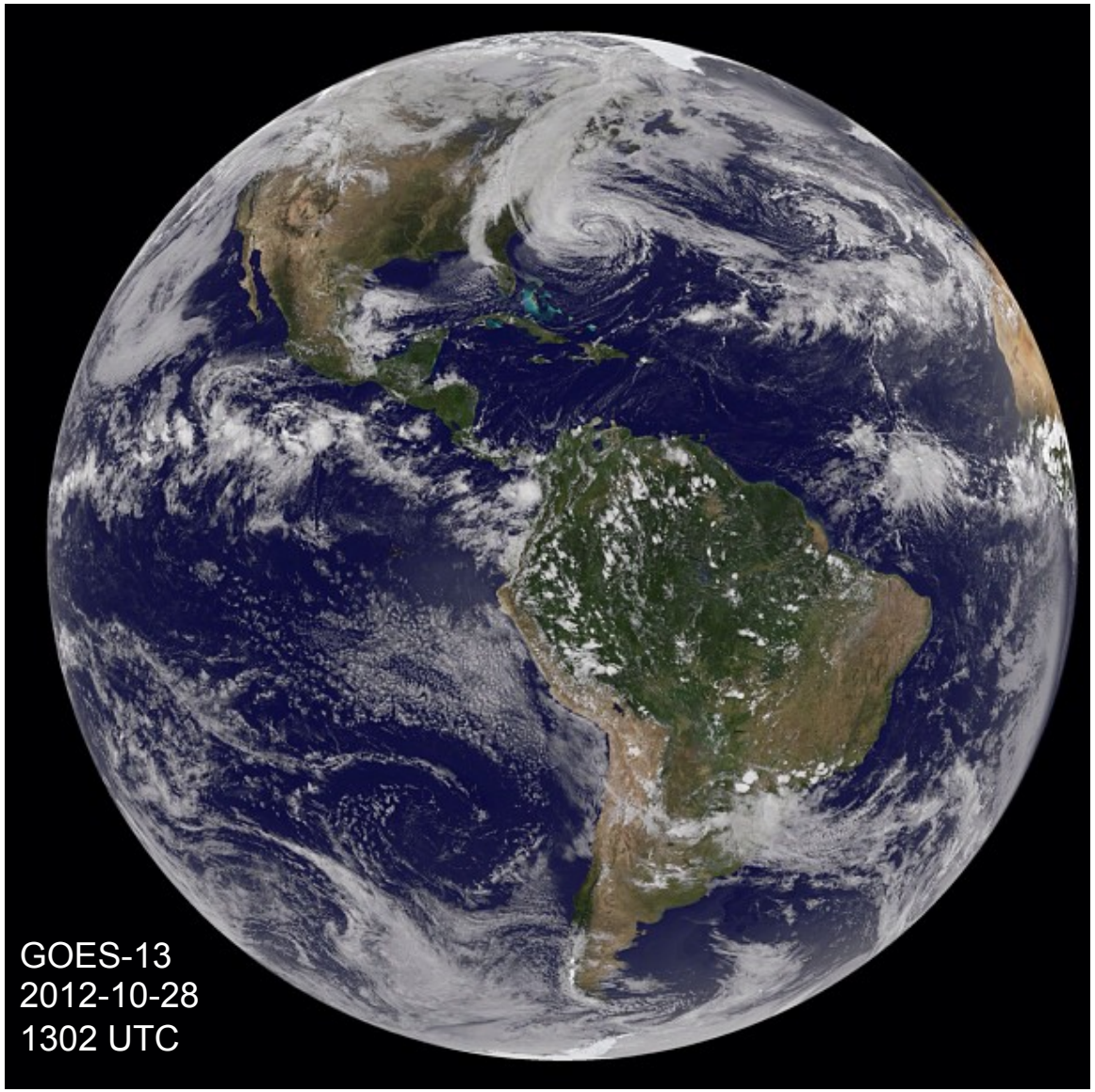
Forcing from Below

The View from Geostationary Orbit

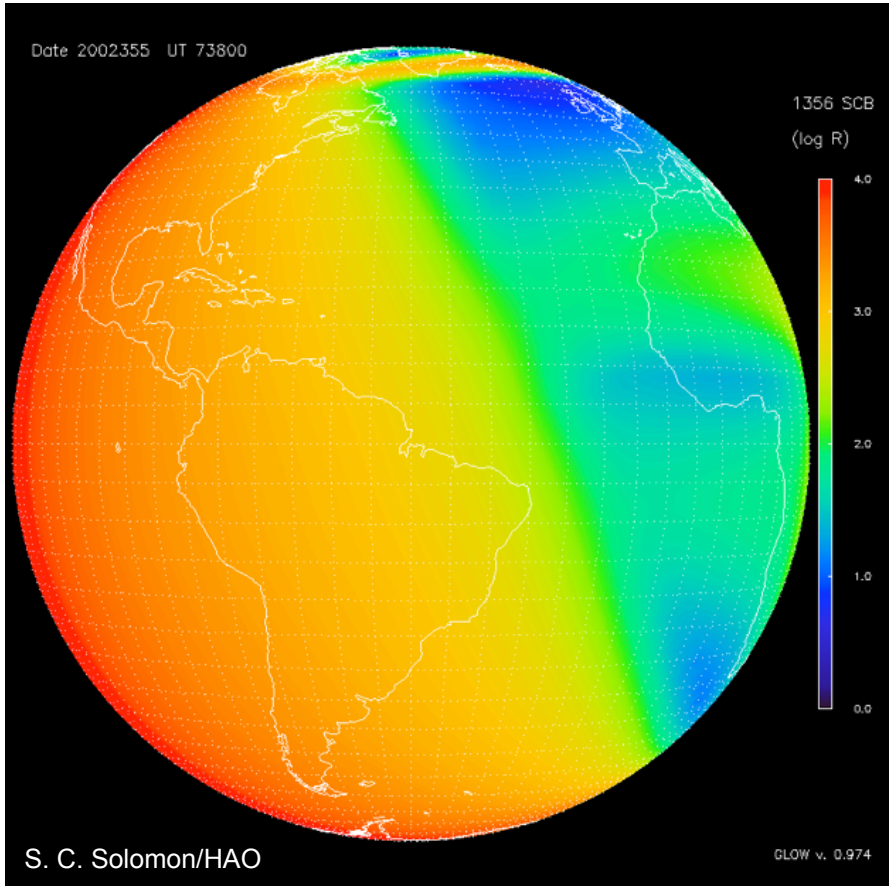
GOLD will make unprecedented images of neutral temperature and composition in the Thermosphere

GOLD images the disk and limb from geostationary orbit

Full disk images at 30-minute cadence



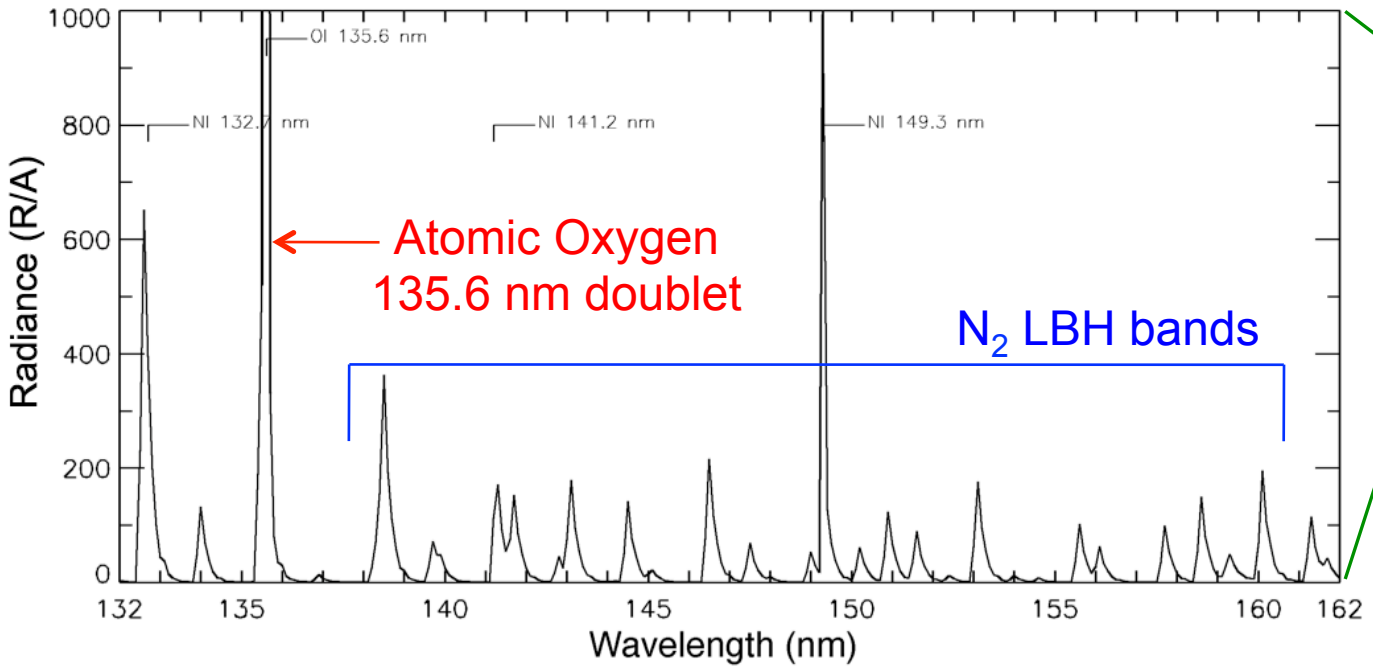
Ultraviolet Imaging from GEO

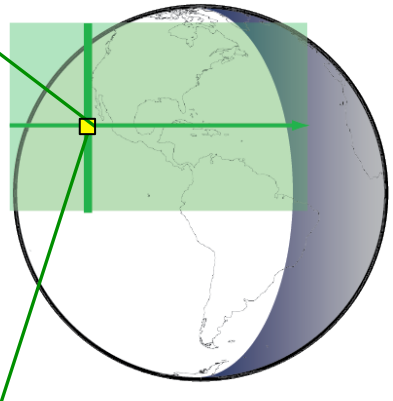


- Simulated GOLD image of oxygen (135.6 nm) emissions
- Simultaneously images N_2 emissions on dayside
- Emissions provide key data for bubbles, thermosphere, and electron densities

GOLD Measurement Technique

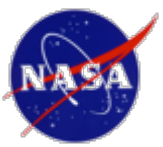
Daytime Far-Ultraviolet Spectrum





Horizontal scan of disk & limb; image along vertical slit

- **Temperature obtained on disk from rotational shape of N_2 LBH bands**
- **O/N_2 composition measured using ratio of 135.6 doublet to LBH bands**
- **Temperature on limb determined by slope of emission altitude profile**
- **O_2 profile on limb from stellar occultations**
- **Nmax at night from 135.6 recombination emission (primarily O^+ + e)**



What to plan for and do early-on to avoid problems later in project's development

To Win and Execute a Science Mission?

- **Great science - which you have or you wouldn't be here**
  - ***World class question(s) that can be answered by the mission***
  - ***Essential for selection to perform Phase A study***
  - ***Fits in NASA's strategic plan***
- **Outstanding Implementation**
  - ***Appropriate and low risk. Heritage and simplicity reduce risk***
    - **Treat heritage with caution**
  - ***Achievable within resources (technical, cost, and schedule) with generous margins***
  - ***Good implementation is critical in Phase A CSR, much more weight than in proposal evaluation***
- **Well developed and defined requirements**
  - ***Requirements are necessary to keep everyone on track***
  - ***Allows design to be optimized early and allows assessment of potential changes***

Phase A (B & C) Lesson – Traceability Matrix (Requirements)

- **An essential tool for communicating the relationship between the science questions, science requirements, measurement requirements and measurement capabilities**
- ***Enables you and others to see the flowdown from science questions to mission and instrument capabilities….and to allocate resources***
- **A key reference for CSR and beyond (e.g., for Level 1's)**

Science Traceability Matrix

Sci. Goal	Sci. Obj.	Scientific Measurement Requirements	Instrument Functional Requirements (Reqmts.)	Projected Performance	Mission Functional Reqmts.
Overarching	Q1	UV disk images of O and N_2 emissions ….	Spatial res.		1. Geostationary orbit 2. …….
			λ res.		
			…		

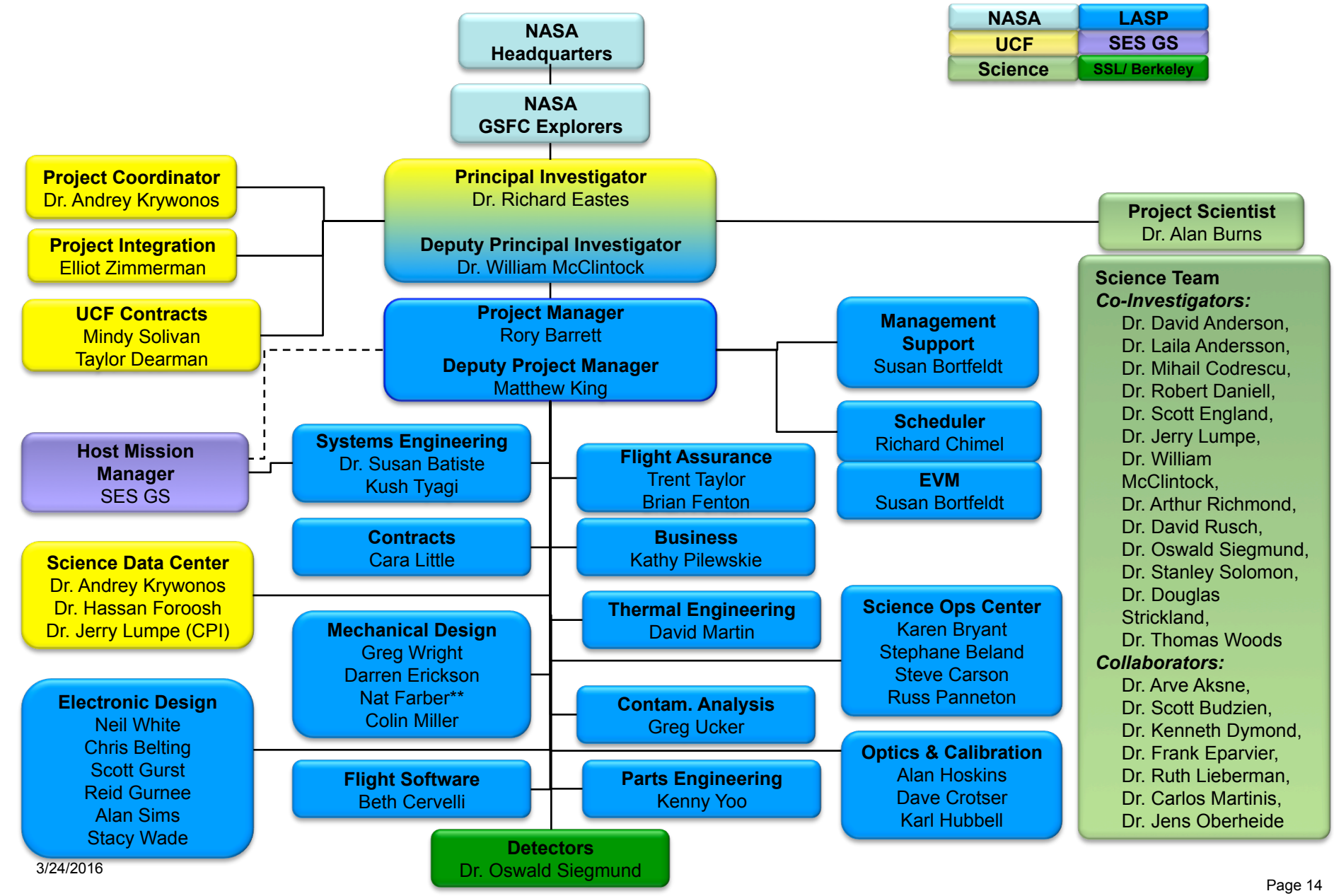
Managing Partners, Managing Contingency, and Descope Philosophy/Approach

Descope Philsophy for MoO

- **GOLD instrument design used two identical channels**
- ***Single channel was capable of productive measurements, but both needed for full capability needed to meet full science (Level 1) requirements proposed***
- **Capability to make productive (threshold) measurements with single channel also enhances reliability of the instrument**

Managing Partners, Managing Contingency, and Descope Philosophy/Approach

GOLD Project Organization

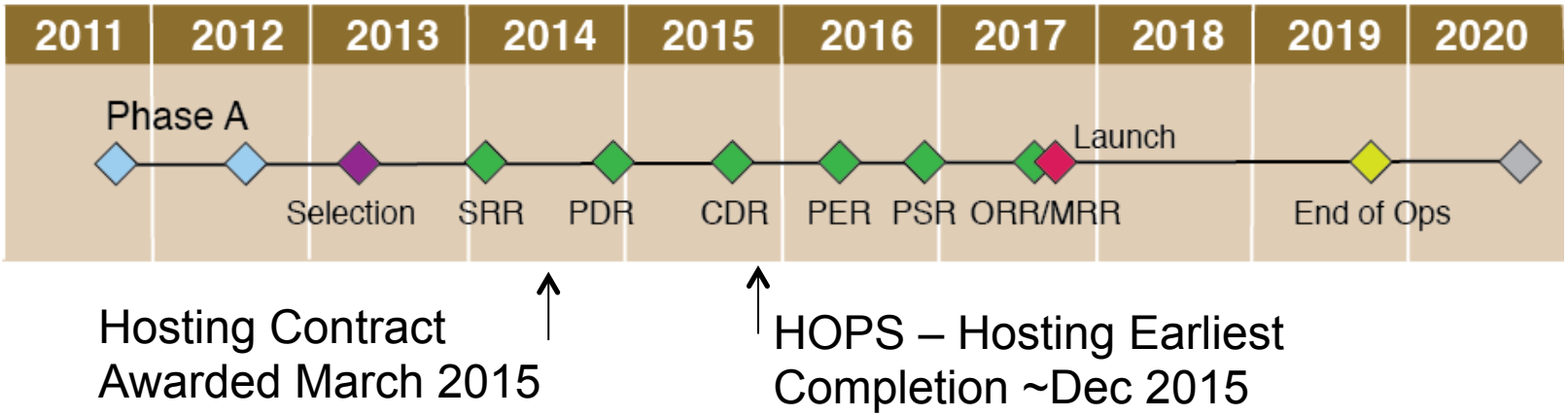


Hosting of Mission (1 of 2)

- **Proposed effort for GOLD included contracting with SES-GS for hosting of mission on an SES satellite**
- ***In preparation for Preliminary Design Review, the need to update accommodation costs was recognized late***
- **Updated cost was $2.5M larger than original ROM**
- ***Raised concerns within program of additional, future increases in costs and that such changes could push mission costs beyond cost cap of $65M for MoOs***

Hosting of Mission (2 of 2)

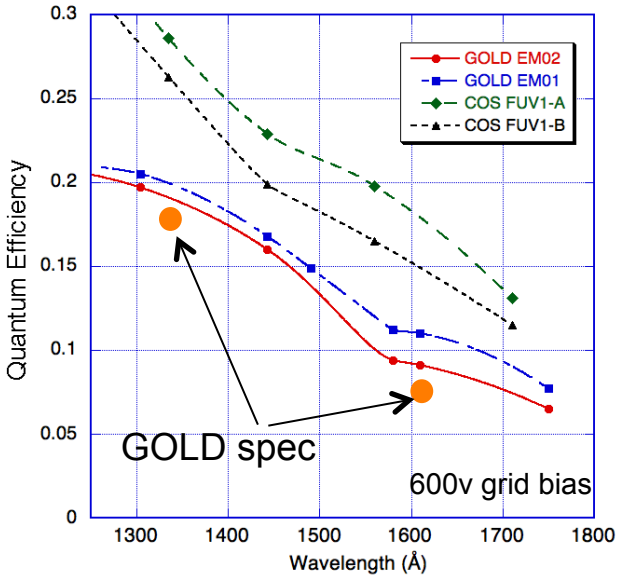
- **Viable plan for hosting and of cost needed before PDR**
- ***Consequently, suggestions that GOLD team consider hosting contract through Air Force HOPS program***
- **Months of digression before recognizing likely delays**
- ***Then resumed effort on hosting contract with SES-GS***



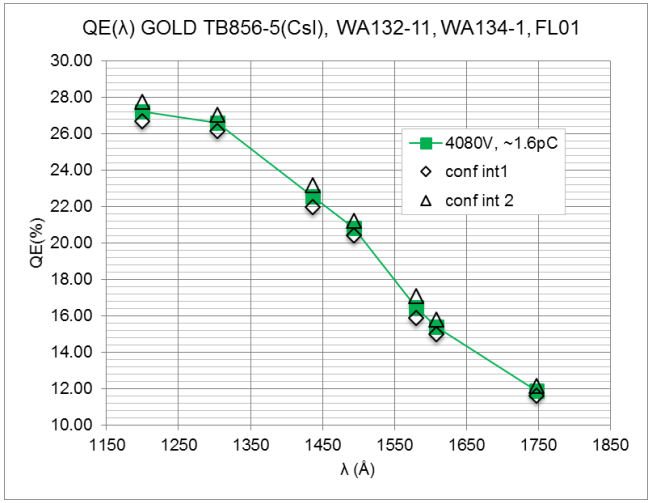
- **Key to successful resolution was clearer communication**

Example 2 – Low QE Detectors

- **Detector QE on engineering model was lower than predicted**
  - Reallocation of sensitivity budget would have eliminated margin on requirements
- ***Were at point where impact to schedule reserve was small (~2 weeks) & repeating later steps in processing would have large schedule impact (next step would have been commitment to low sens)***
- **Allowed time to explore reason for low sensitivity and options for sensitivity increase**
- ***Good communication enabled team to allow time needed for analysis***



Engineering Detector



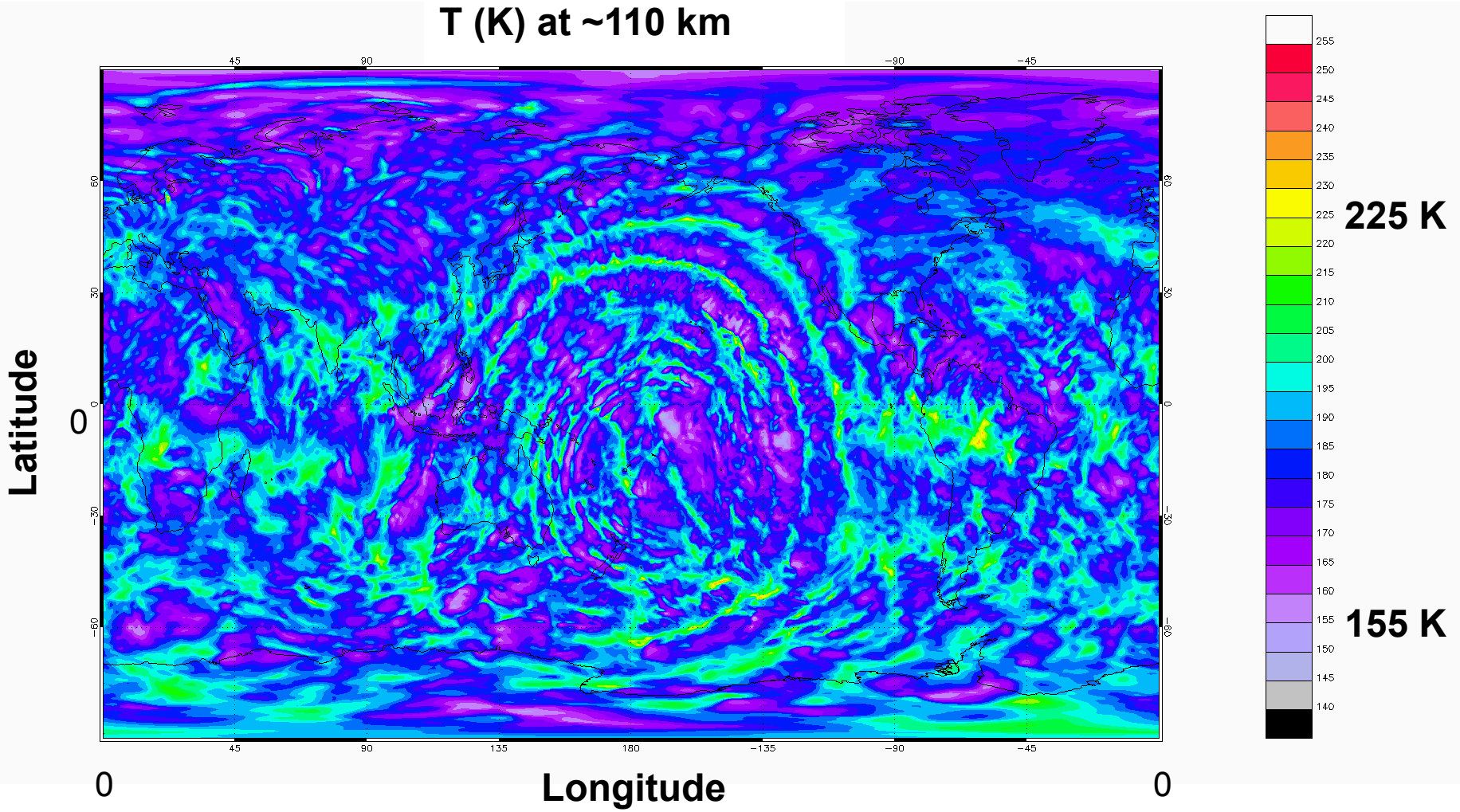
Flight Detector

In Conclusion

- **Well developed requirements are a key to understanding and communicating how to best use resources**

- **Broad and effective communication benefits the mission in managing partners and managing contingency**

Forcing from Below in Typhoon



WACCM Calculation of Gravity Waves at High Resolution (0.25° Spatial by 0.1 Scale Height)

3/2 From: Hanli Liu at NCAR/HAO