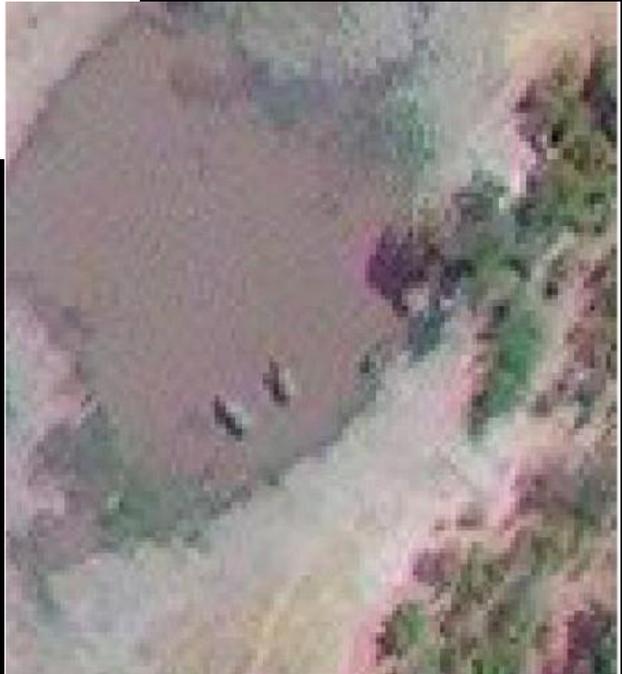


Grand Challenge Tutorial
Concert:
Coordinated Ground and Space-based
Observations of the Ionosphere-
Thermosphere System

Katelynn Greer

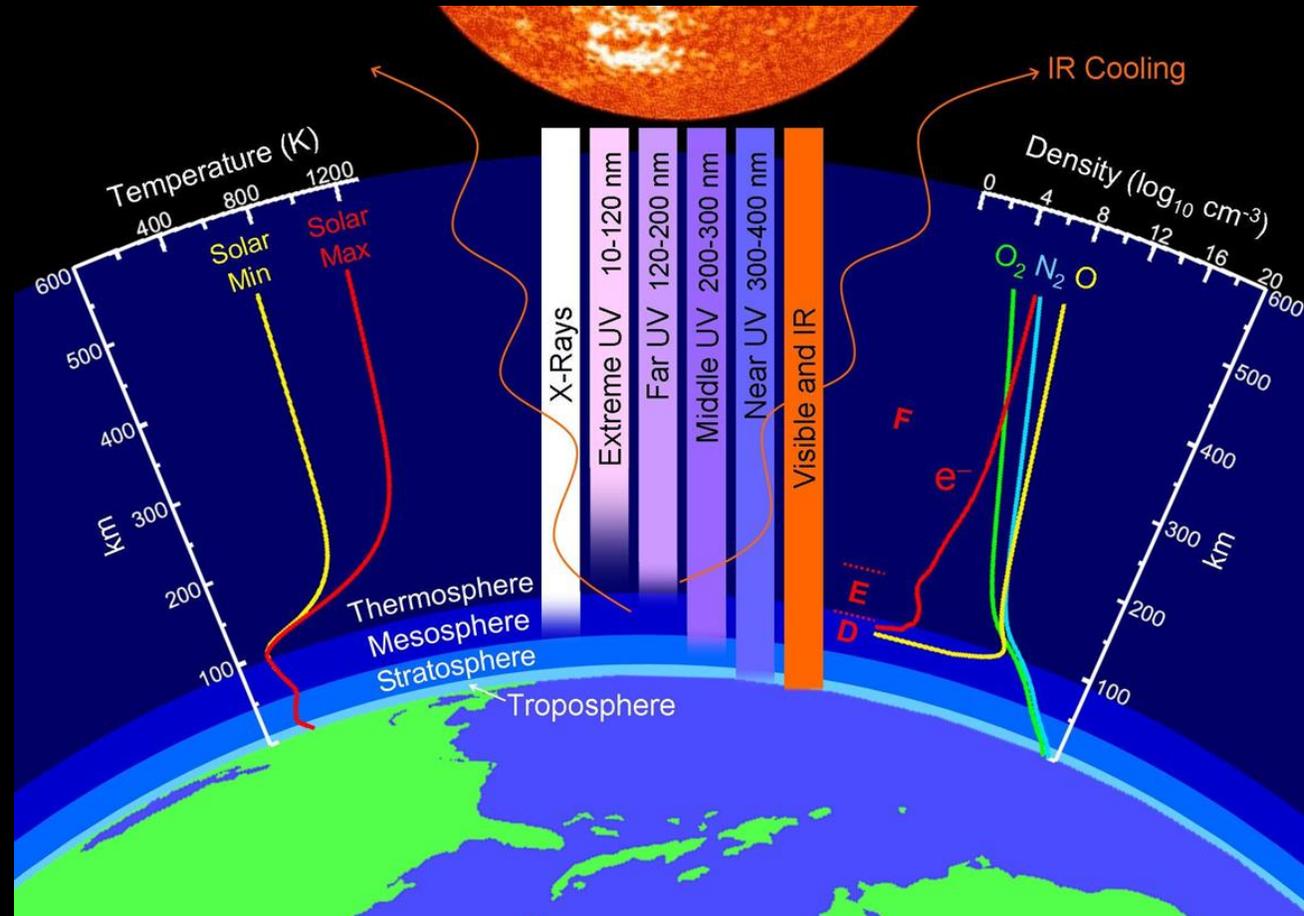
Alan Burns, Scott England, Iurii Cherniak, Carlos Martinis, Wenbin Wang



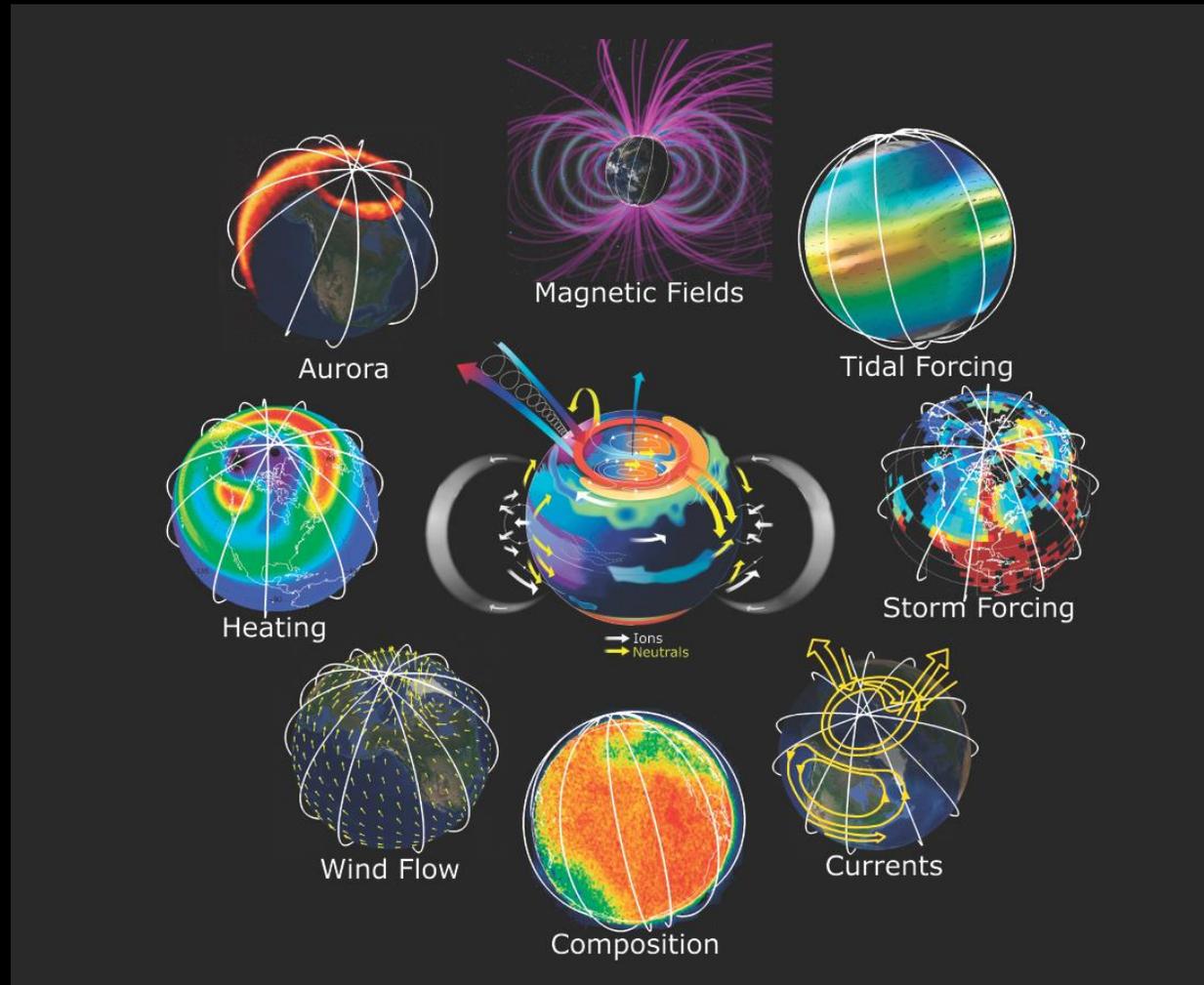
Grand Challenge:

Integrate Different Views to Get A
Comprehensive Understanding

What's our Elephant?

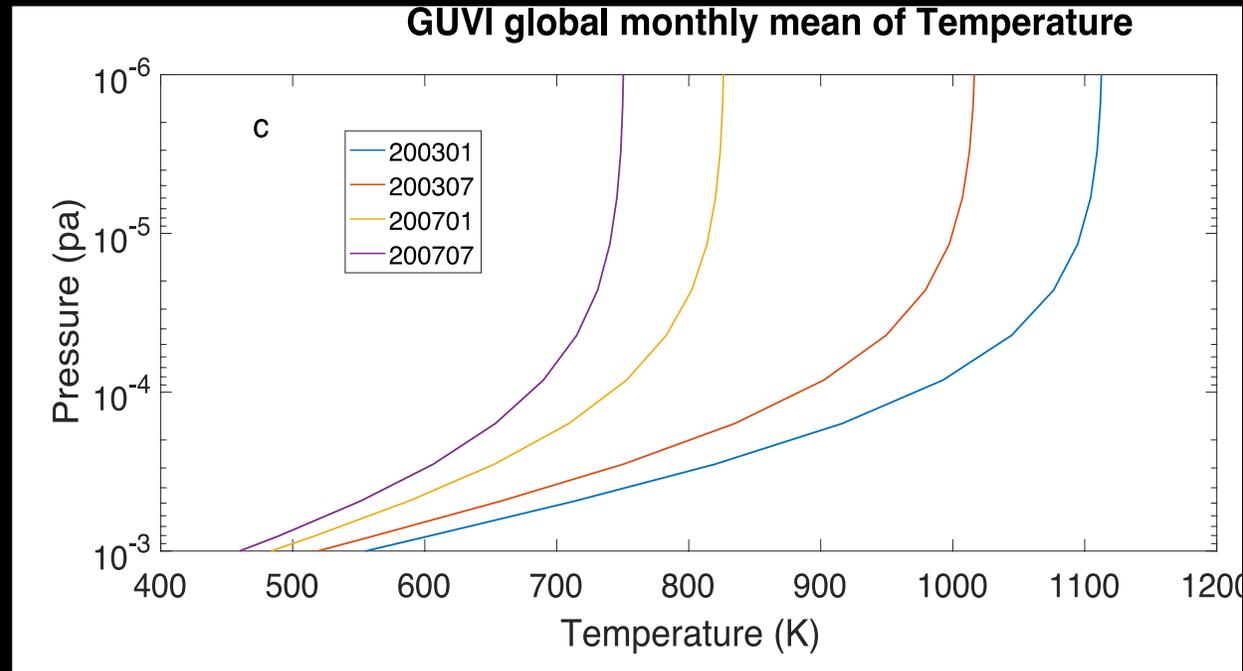


What We Know: It's a Complex System



What We Know: Climatology

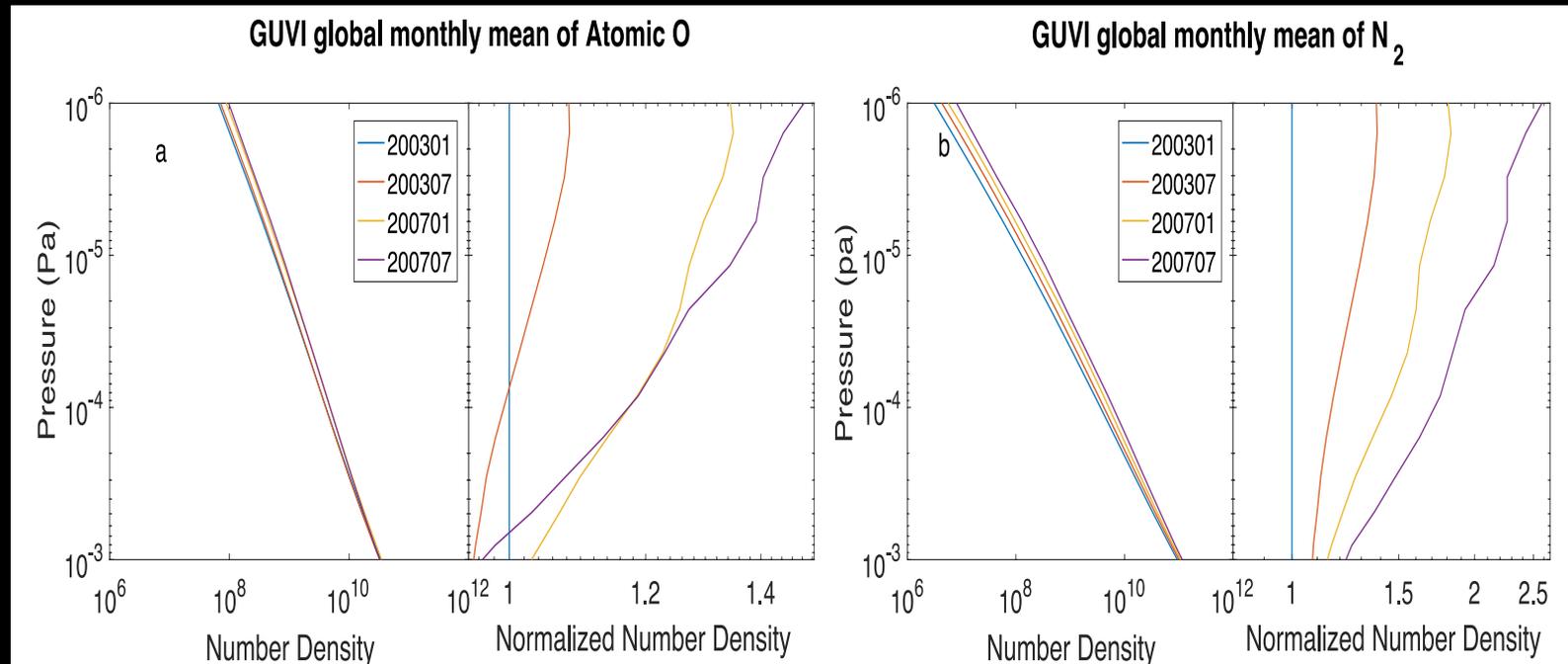
- Temperatures



Yue et al., 2019

What We Know: Climatology

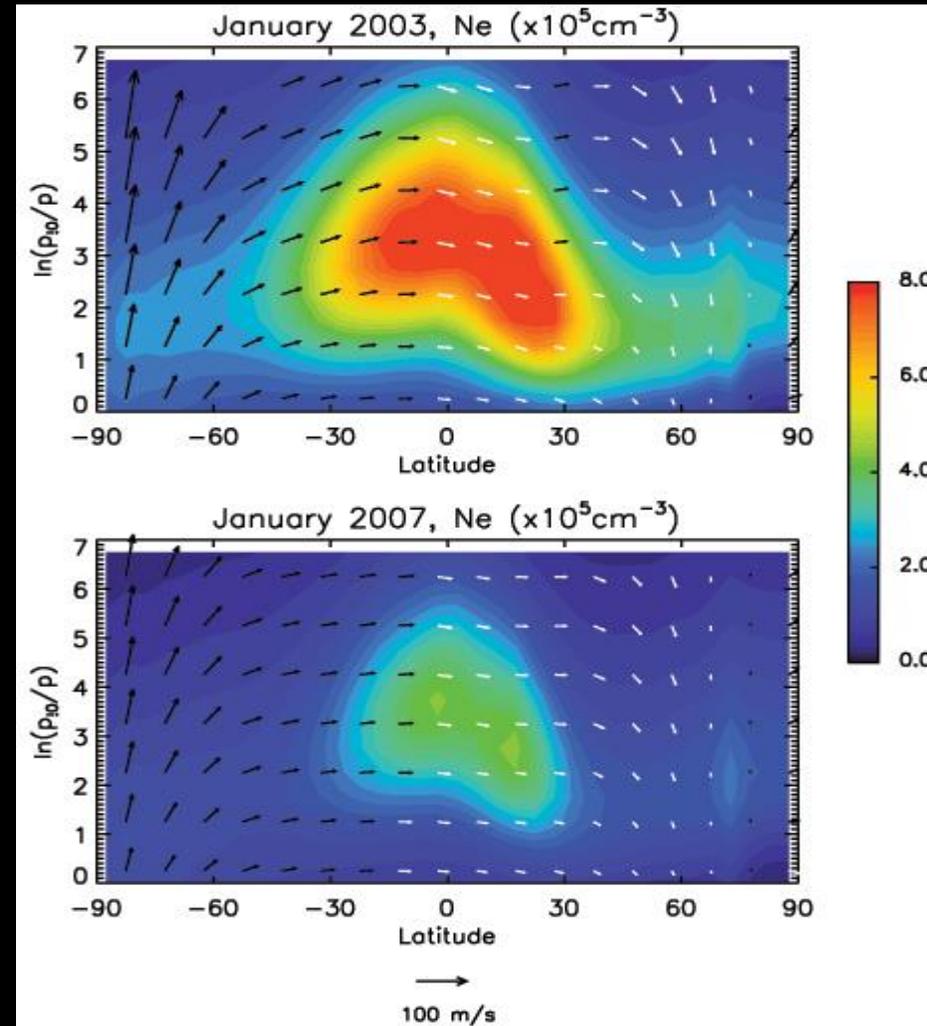
- Composition



Yue et al., 2019

What We Know: Climatology

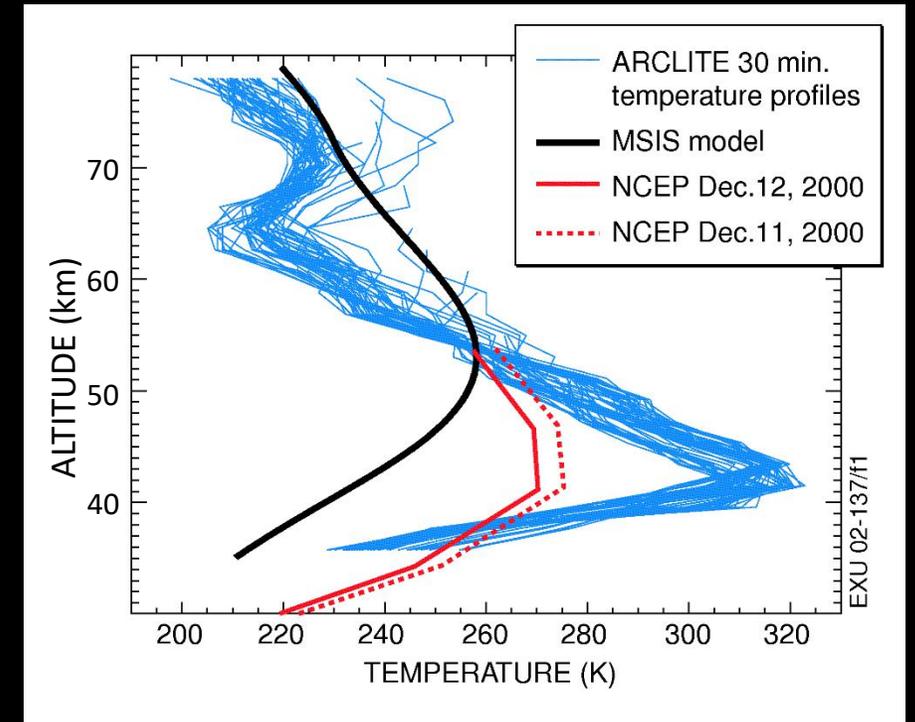
- Winds & Plasmas



Qian et al., 2016

What We Don't Know...

- Weather vs Climate
- Separating Spatial and Temporal Variability
- Develop locally or drift into view



Thayer & Livingston, 2008

What We Don't Know...

- Composition
 - How does O and N₂ vary and what is their relationship to the ionosphere?
 - How does total neutral density vary?
 - How do minor species in the thermosphere vary and what are their roles in cooling the thermosphere?
 - How do total solar eclipses affect the composition?
 - How does the thermosphere respond to variations in EUV?
 - What is the influence of composition changes on the ionospheric F2 peak and the topside ionosphere?
 - How does the transition from a mixed to a heterogeneous atmosphere occur?
- Storms
 - What is the composition change during geomagnetic storms?
 - How can we forecast the impact of flares, CME's and coronal holes on Earth's thermosphere and ionosphere?

See Rishbeth, 2004; Prölss, 2006; Burns et al., 2007

What We Don't Know...

- Lower Atmospheric Forcing
 - What gravity waves make it into the thermosphere? What momentum do they contribute to the thermosphere?
 - What are the tides in the thermosphere?
 - What role do Solar Terminator Waves play in agitating the thermosphere and ionosphere?
 - Are there planetary waves in the thermosphere?
- Plasma Structures
 - What seeds plasma bubbles? And can we develop a method of forecasting them?
 - What influences the formation and evolution of the Equatorial Ionospheric Anomaly?
 - What causes the asymmetry in the Equatorial Ionospheric Anomaly?
 - Is there longitudinal variability in the thermosphere and ionosphere?
 - How well are the night electron density and conductivity really known?
- Aurora
 - How is the phenomena “Steve” related to our understanding of auroral activity?
 - How is energy from the high-latitude regions transferred to other parts of the globe?

See Rishbeth, 2004; Prölss, 2006; Burns et al., 2007

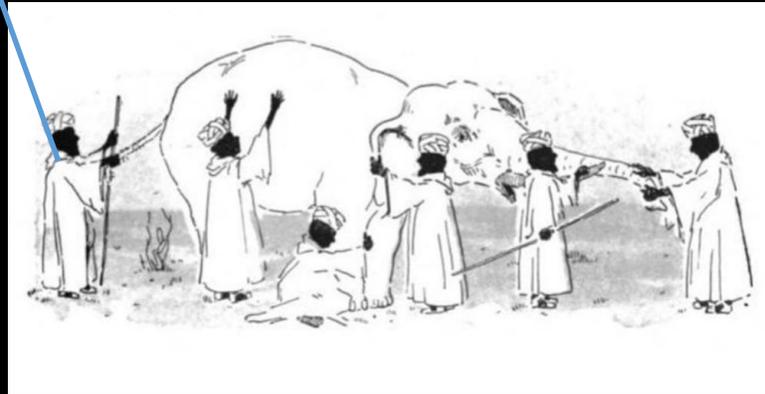
What Elephant “Investigators” Do We Have?

Ground-Based



What Elephant “Investigators” Do We Have?

Lidar



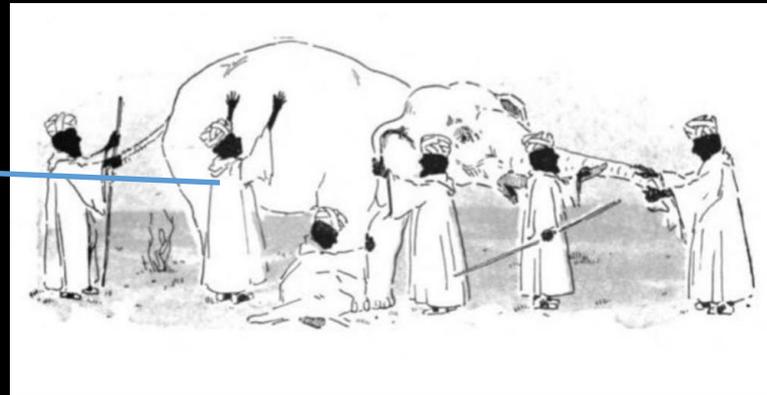
- **Instruments**
 - Alomar
 - McMurdo
 - USU
 - CU-Boulder
 - Cerro Pachon
 - Arecibo
 - Many stations around the world
- **Data**
 - Point Profiles of temperature, densities, winds

What Elephant “Investigators” Do We Have?

Incoherent Scatter Radar



Millstone Hill



- **Instruments**

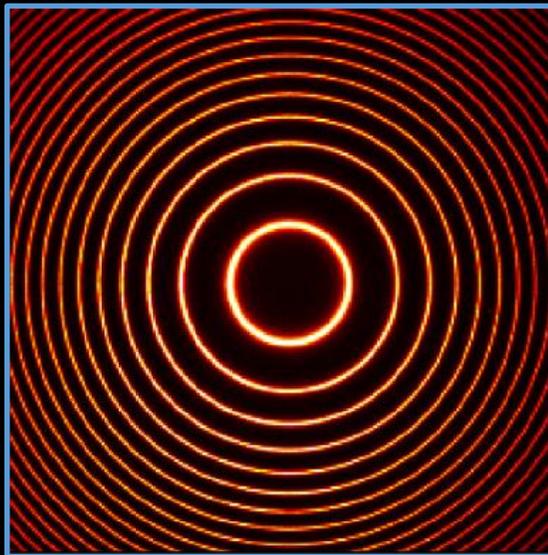
- Millstone
- Jicamarca
- Arecibo
- AMISR
- Resolute Bay
- EISCAT

- **Data**

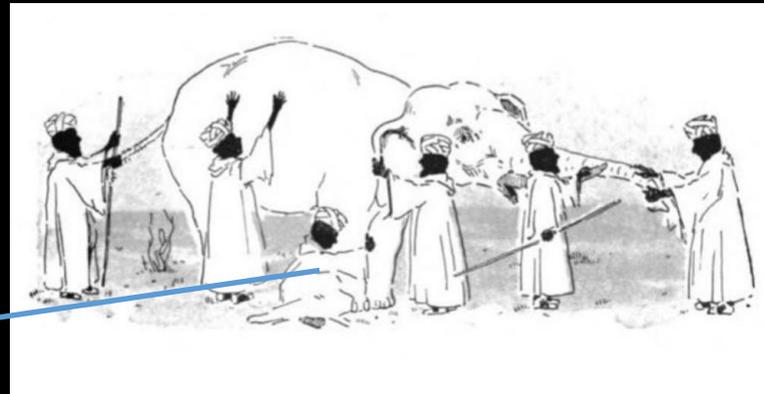
- Ion velocities, plasma density profiles, electron and ion temperatures
- Electric field, winds

What Elephant “Investigators” Do We Have?

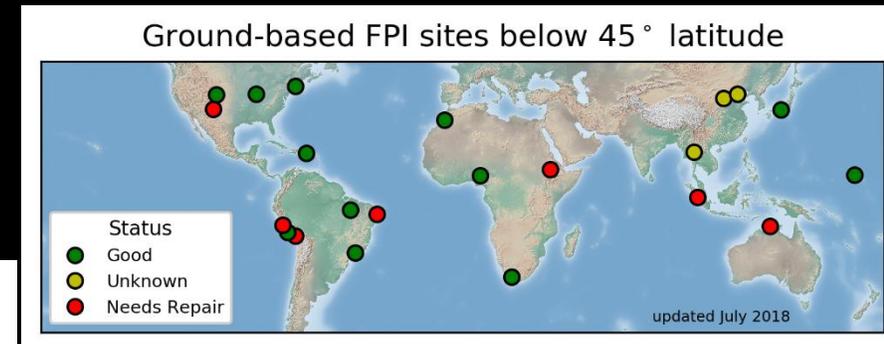
Fabry-Perot Interferometer



K. Greer



- **Instruments**

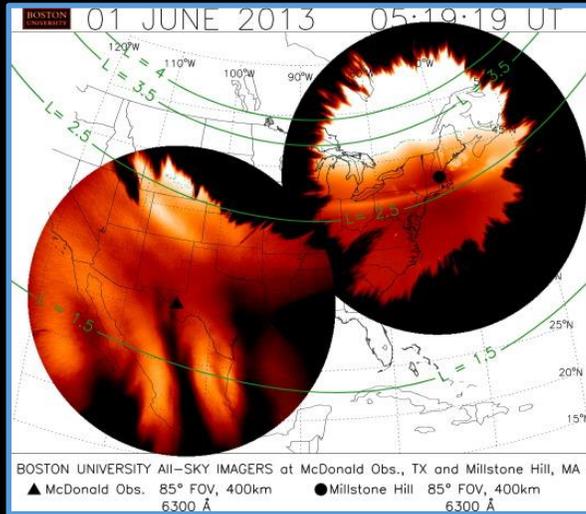


- **Data**

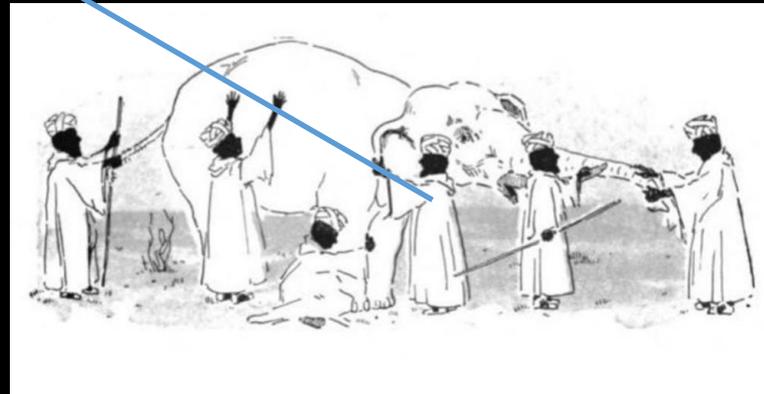
- **Nighttime Temperature 200-270km**
- **Wind**

What Elephant “Investigators” Do We Have?

All-Sky Imagers



C. Martinis



• Instruments

- THEMIS
- REGO
- BU
- SRI
- INPE
- UNIVAP

• Data

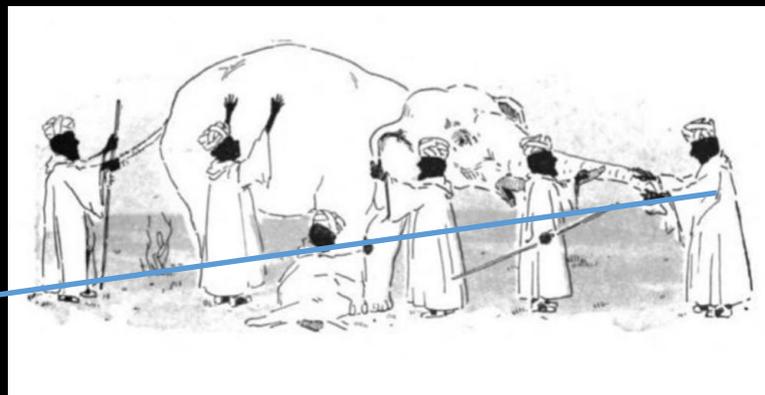
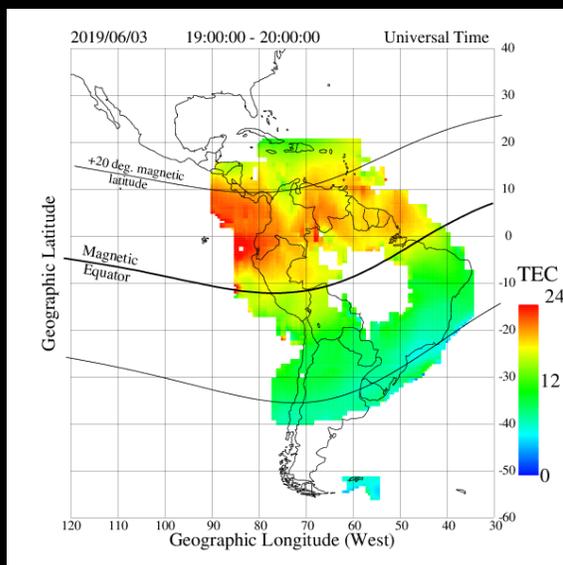
- Gravity waves
- Auroral features
- Particle precipitation
- Equatorial Ionization Anomaly

What Elephant “Investigators” Do We Have?

GNSS

- Instruments
 - Networks of scientific grade receivers
- Data
 - TEC
 - Scintillation

LISN



What Elephant “Investigators” Do We Have?

Data Assimilation & Models



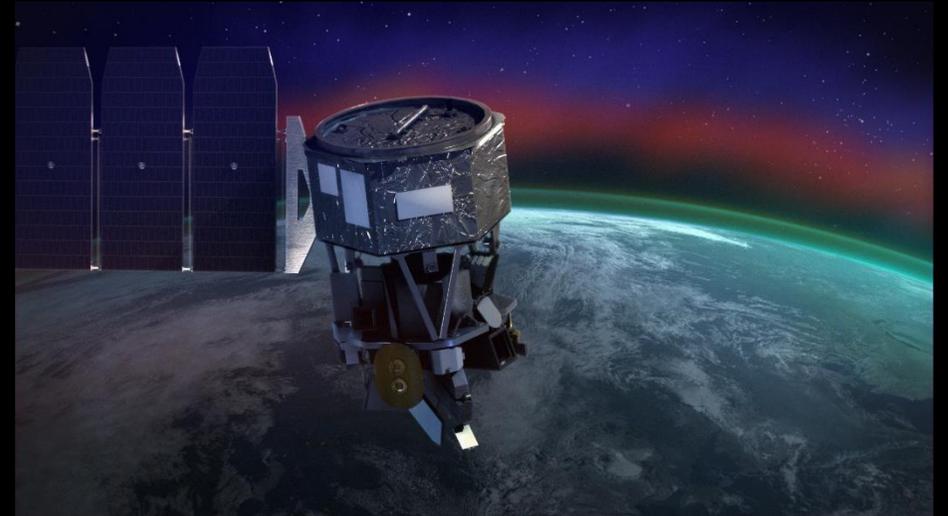
- **General Circulation Models**
 - TIE-GCM
 - WAM
 - WACCM-X
 - GITM
- **Data Assimilation Schemes**
 - Fusion of model and data



What Elephant “Investigators” Do We Have?

ICON

- **MIGHTI**
 - Temperature and velocity of thermosphere
- **IVM**
 - Ion Velocity
- **EUV**
 - Height and density of daytime ionosphere
- **FUV**
 - Thermosphere composition and nighttime density of ionosphere





What Elephant “Investigators” Do We Have?

COSMIC-2

- **Joint Taiwan/US Mission**
- **Radio Occultations**
 - 6 satellites with JPL TriG receivers and high-gain antennas
 - 5000 soundings per day
 - Low and mid-latitudes
- **TEC Measurements**
- **IVM and RF Beacon Payloads**





What Elephant “Investigators” Do We Have?

• Host Mission

- SES-14, in geostationary orbit over mouth of the Amazon River (47.5°W)

• GOLD Instrument

- Two identical, independent imagers
- Each observes disk and limb in UV

• Data

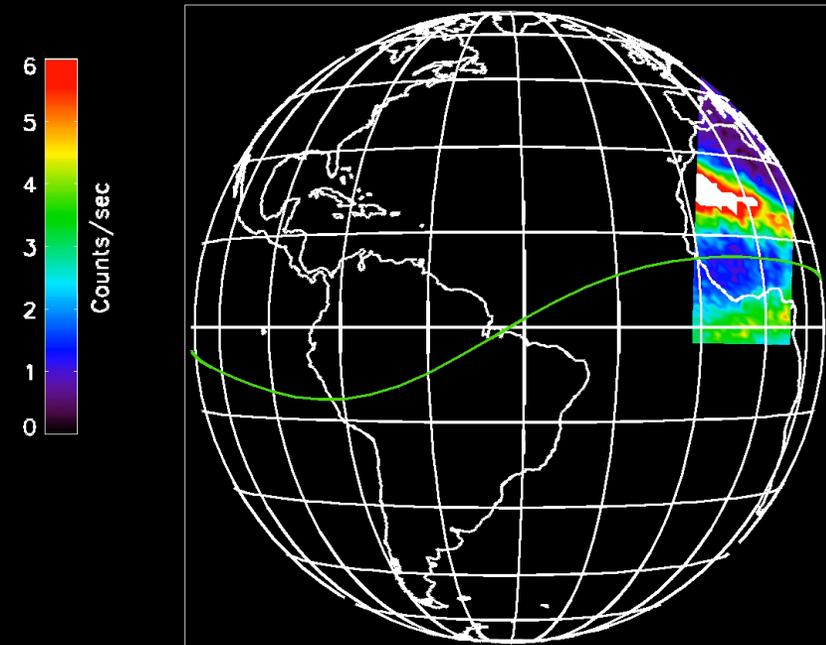
- Earth’s disk images
 - Daytime: Radiance, temperature and composition of thermosphere
 - Nighttime: Density of ionosphere
- Earth’s limb
 - Temperature and densities in the thermosphere

GOLD

2019-080

GOLD
(0.0N, 47.5W)

2019.03.21



<http://gold.cs.ucf.edu/>

1700 GOLD LT

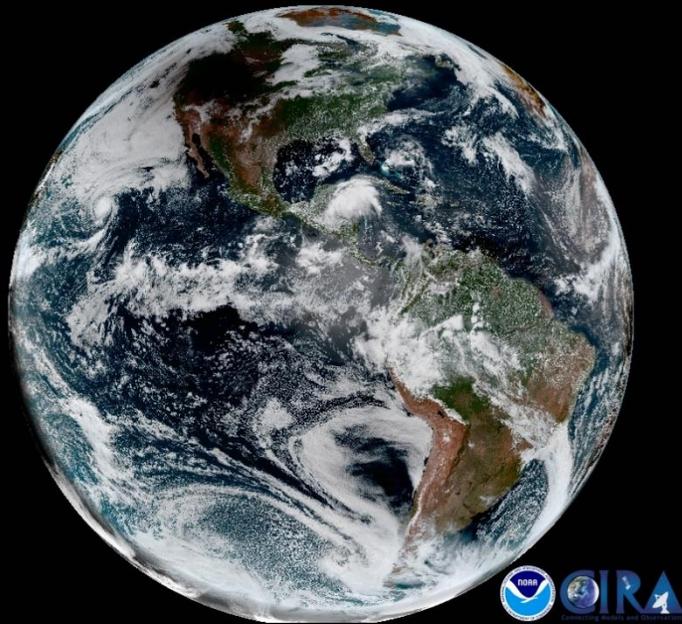
2010 UT

slit width: 1.00 × original LR width

CHALLENGE CALL

Coordinated Ground and Space-based Observations of the Ionosphere-Thermosphere System

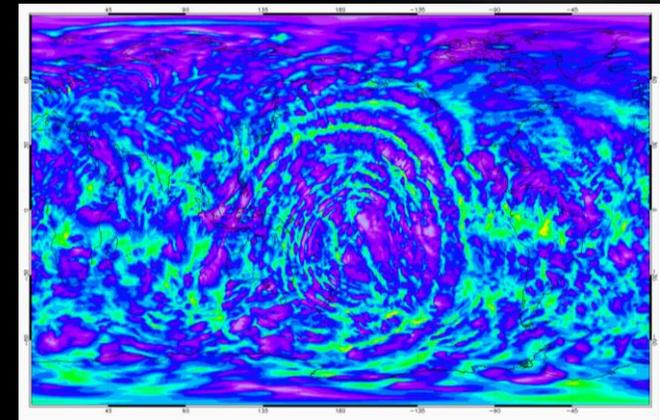
Year 1 Objectives: Initial sharing of current observation capabilities



- **Survey of current**
 - **ground-based instruments**
 - **space-based assets**
 - **models/data assimilations**

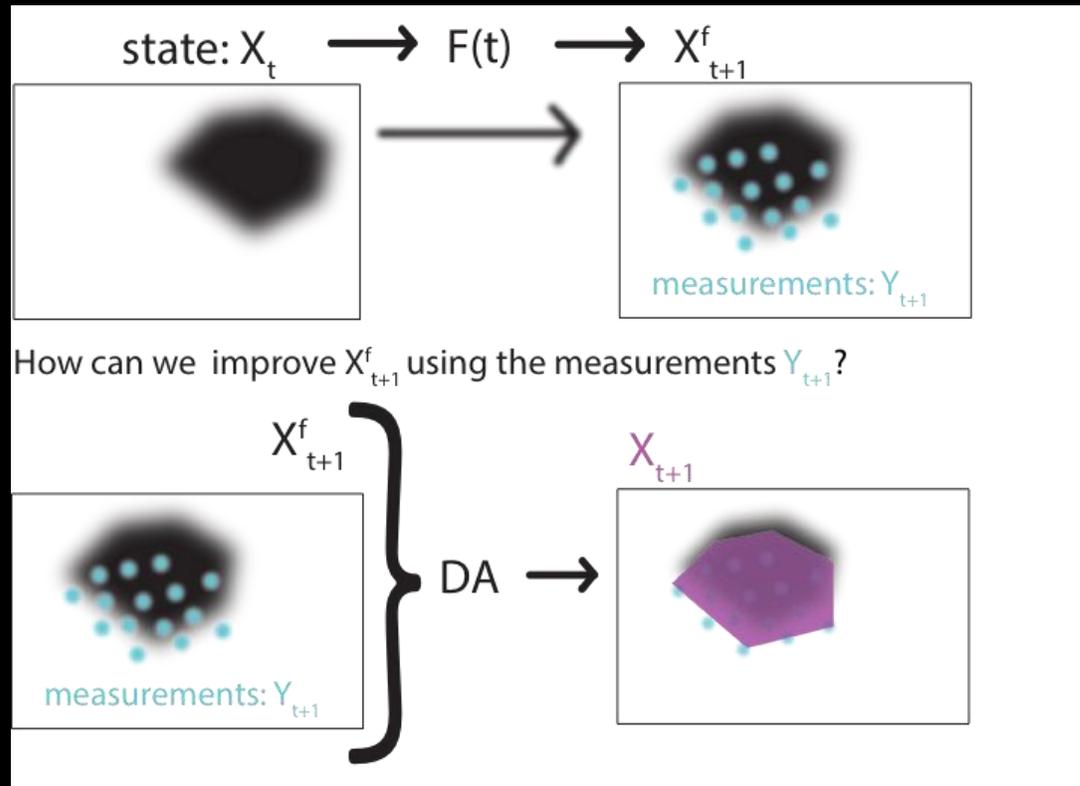
Year 1 Objectives: Development and dissemination of a timeline of planned activities

- Total Eclipses
 - July 2, 2019
 - Co-incident with international campaign
 - December 14, 2020
- Gravity wave experiments
 - Atlantic hurricane season
 - SouthTrack campaign
- Whole Heliosphere & Planetary Interactions
- Madrigal Database ISR campaigns



Liu et al., 2014

Year 1 Objectives: Theoretical support of observational campaigns



Codrescu

Year 1 Objectives: Access to both data taken and time lines of upcoming events

- Webpage detailing campaigns
 - Where to find data!
- Madrigal (?)

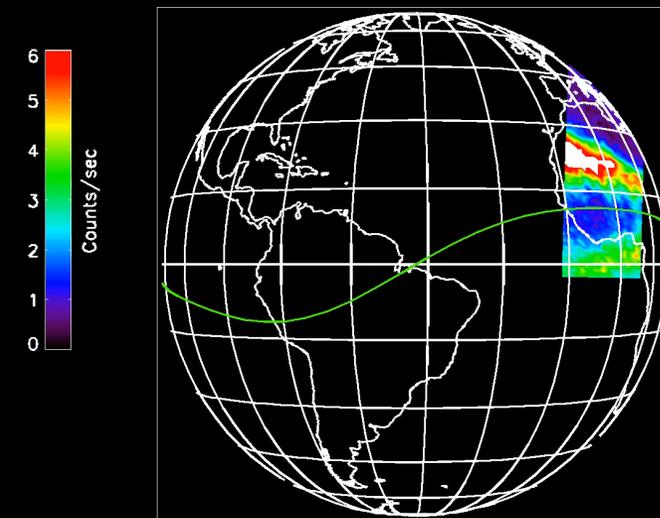


Grand Challenge will only be successful with CEDAR community participation

CONCERT A/B

- Monday TODAY 13:30-15:30
 - Mesa-A
 - Update on COSMIC-2
- Tuesday TOMORROW 10:00-12:00
 - Mesa-A
 - Updates on GOLD & ICON
- katelynn.greer@lasp.colorado.edu
- aburns@ucar.edu

2019-080 GOLD 2019.03.21
(0.0N, 47.5W)



1700 GOLD LT

slit width: 1.00 × original LR width

2010 UT