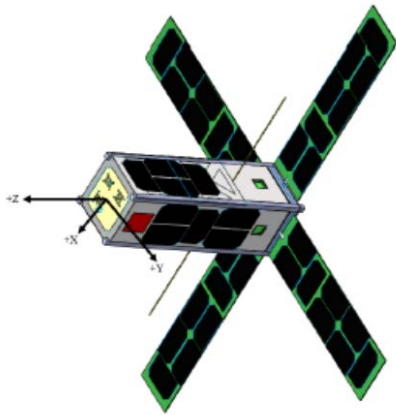
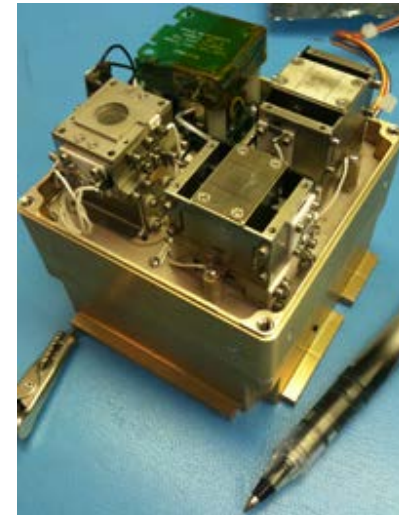


# Cubesat Investigating Atmospheric Density Response to Extreme Driving (CADRE)



Scott Perry, James W. Cutler,  
Aaron Ridley, Tom Heine

University of Michigan

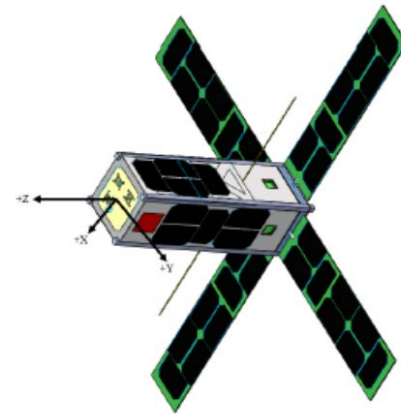


Andrew Nicholas

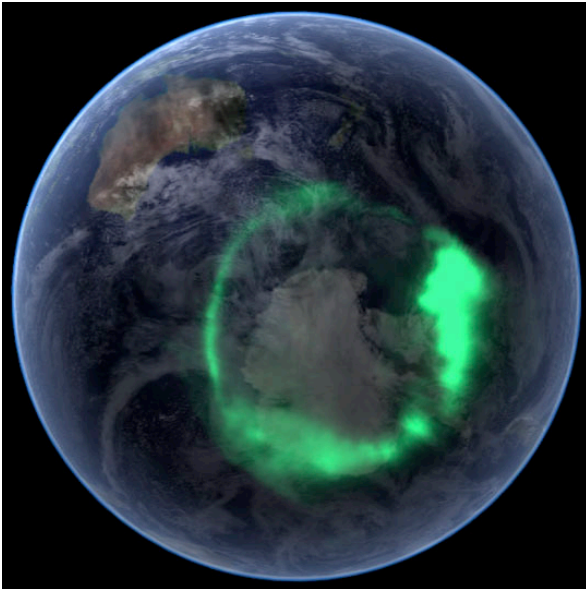
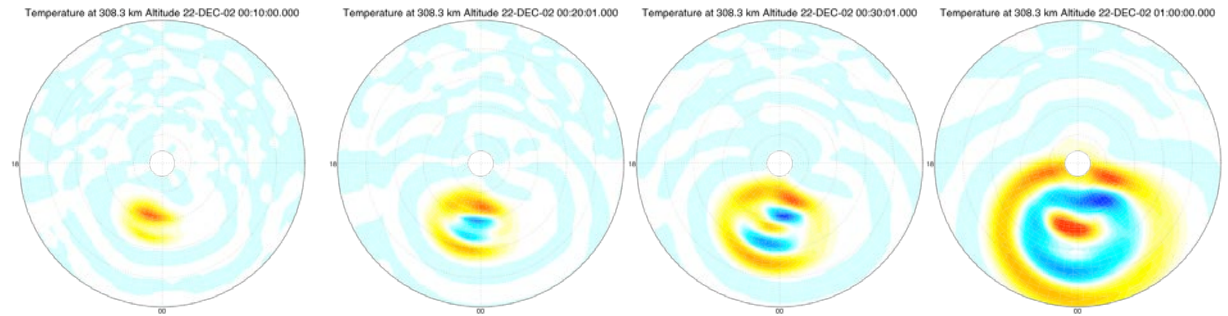
Naval Research Laboratory

# Mission Overview

- NSF funded space-weather mission
  - Understand the upper atmospheric response to auroral energy input
- Team
  - University of Michigan
  - Naval Research Laboratory
  - NASA Goddard Space Flight Center
- 3U Cubesat
  - Deployable panels
  - GPS
  - 3-axis stabilized
  - High rate communication
- Launch date is to be determined



# Science Background: Upper atmospheric heating due to currents and the aurora typically take place on small-scales, but over a very broad region

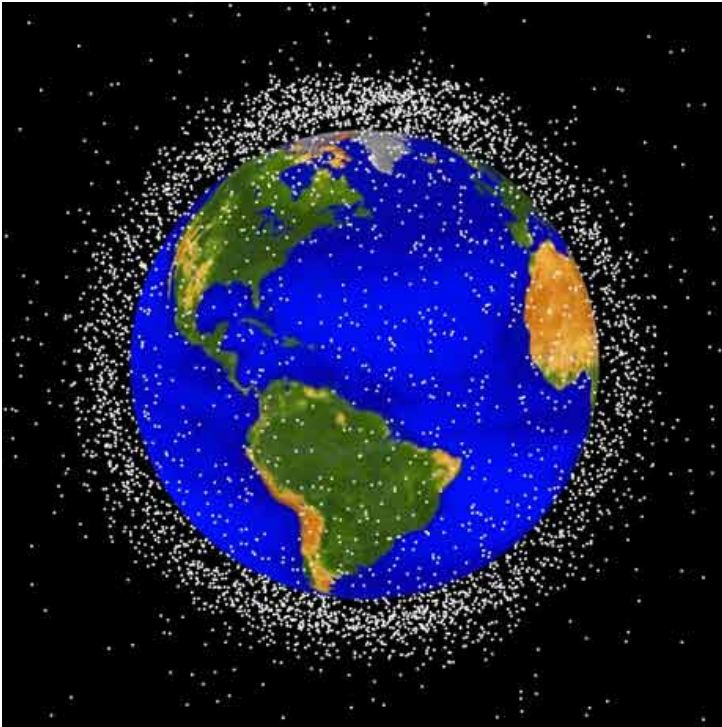


We have a very limited understanding of this...

# Science Goal: Understand the upper atmospheric response to auroral energy input

- We will attempt to answer the following questions:
  1. What are the scale sizes of thermospheric gradients in the auroral zone?
  2. How does the thermospheric response to energy input spread away from the location of that input?
  3. What are the interhemispheric asymmetries in the response of the thermosphere to energy input?

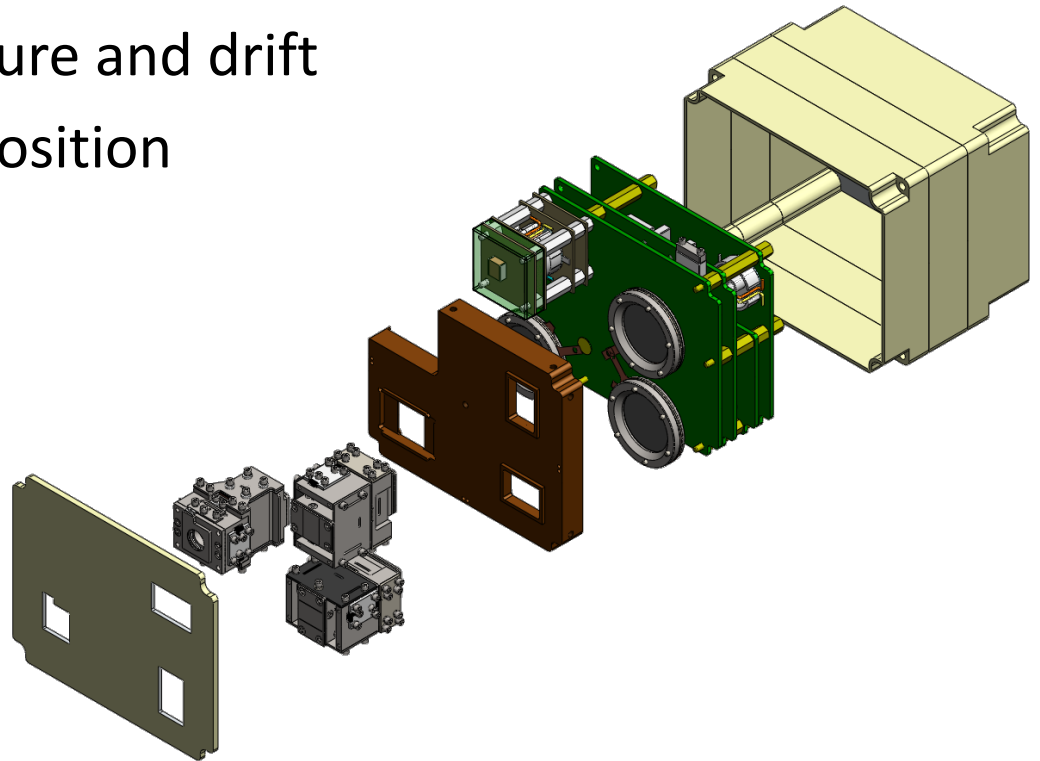
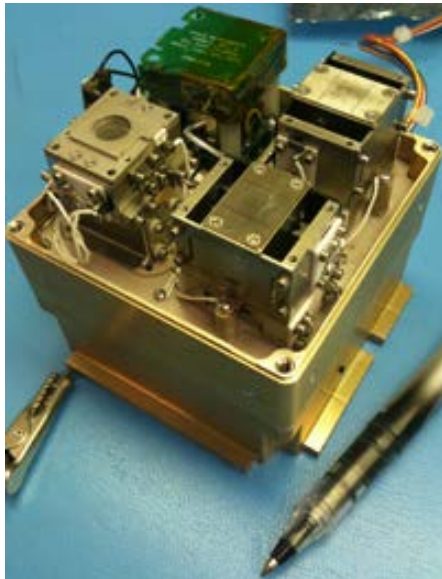
# Societal Importance: Better orbital prediction of LEO satellites during times of strong solar driving



- Estimated >13,000 objects larger than 10cm diameter
  - After solar storms, 1000s of objects are “lost”
  - CADRE-like missions will measure global scales of ionosphere response
  - Modelers will be able to better predict
- 
- Resulting in a vast improvement in our capability to trace space debris

# Primary Payload: NRL/Goddard built Wind Ion Neutral Composition Suite (WINCS)

- GSFC and NRL developed Wind Ion Neutral Composition Suite measures:
  - Neutral density, temperature and wind
  - Ion density, temperature and drift
  - Ion and neutral composition

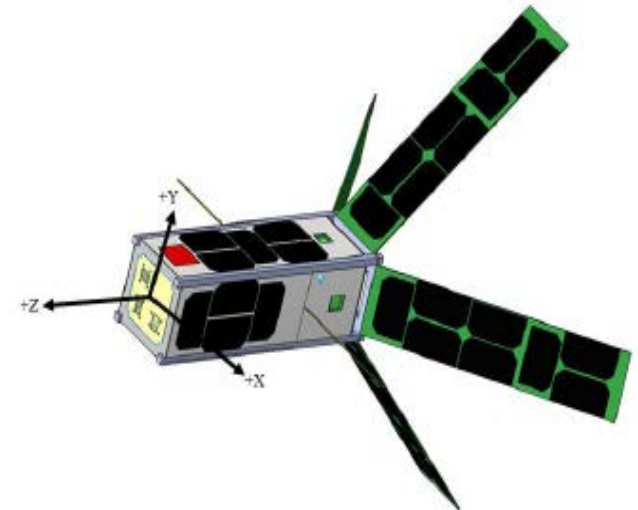
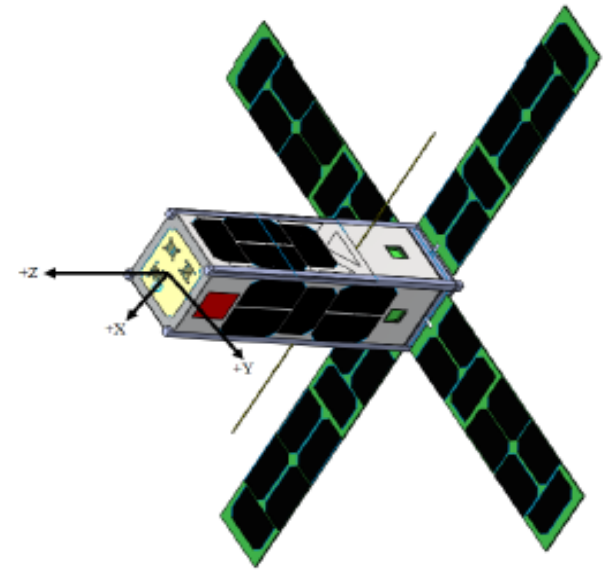


# Primary System Drivers: Three axis stabilization and high data rate collections

- WINCS requires pointing in the “ram” direction
  - Pointing knowledge within  $0.2^\circ$
  - Pointing control within  $2^\circ$  of ram
  - Roll shall not exceed  $0.1^\circ/\text{min}$  about the Z-axis
- Base payload data rate is 280 MB / day
  - Reduction possible through compression and averaging.
- These require an extremely capable CubeSat system

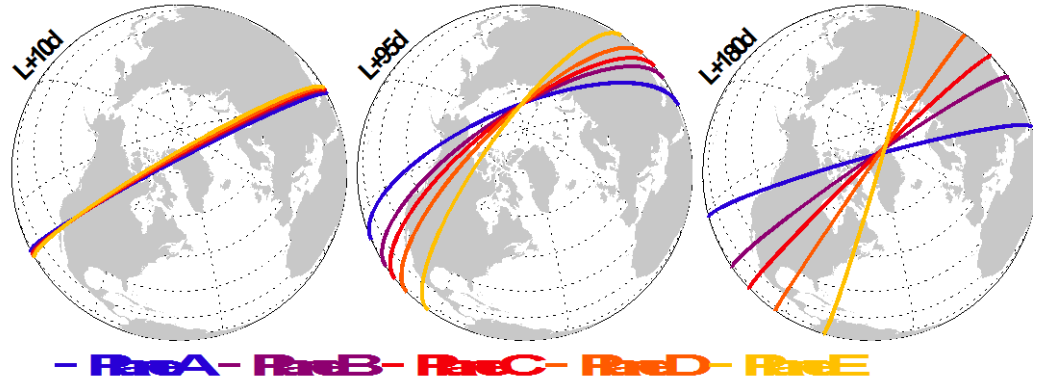
# Initial Mission Architectures

- Developing design optimization techniques to maximize power generation and communication.
- Attitude determination
  - Star tracker
  - Sun sensors
- Attitude control
  - 3 axis wheels
  - Magnetic coils
- High speed communication over S-Band ( >1 Mbps)
- Dual frequency GPS

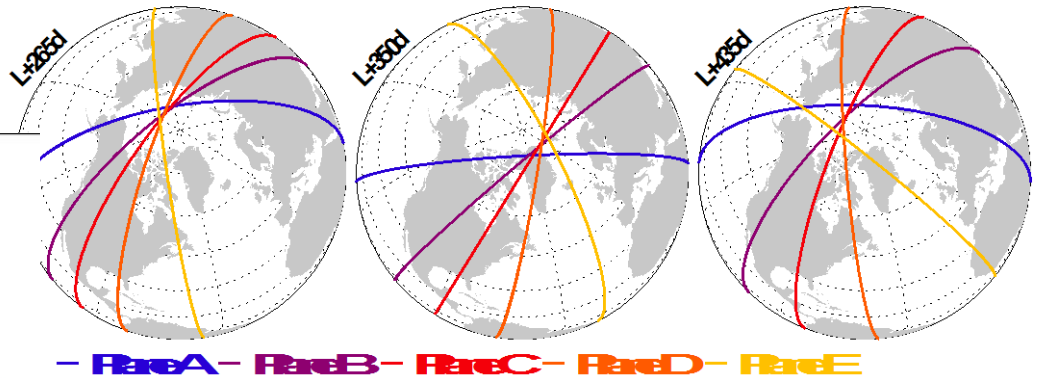
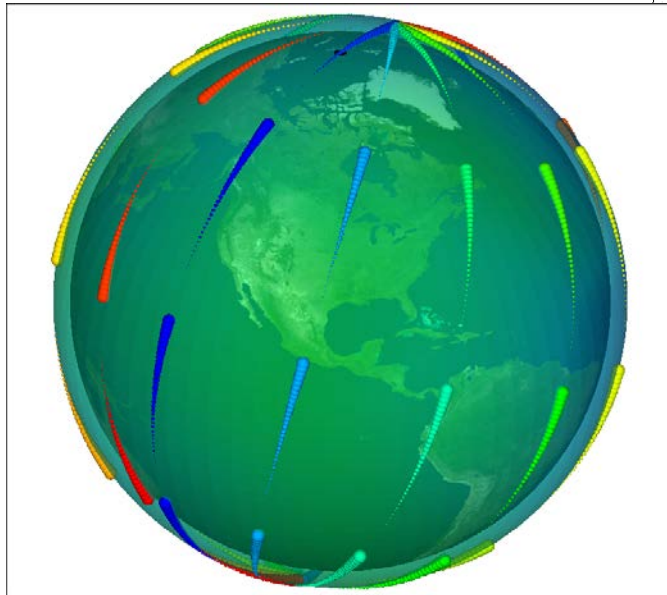




# CADRE is a precursor to a larger mission concept -- ARMADA



## 48 Satellites - ARMADA



# Current Status

- CADRE has been selected by NSF as one of their space weather CubeSat missions
- CADRE is part of AFOSR's University Nanosatellite Program (NS-7)
- Initial concepts developed
  - Detail mission design to begin Fall 2011
- Launch has not been identified, yet
  
- CADRE is ARMADA\_0
  - Goal is global thermospheric monitoring