Global System For Monitoring Earth Radiation Balance

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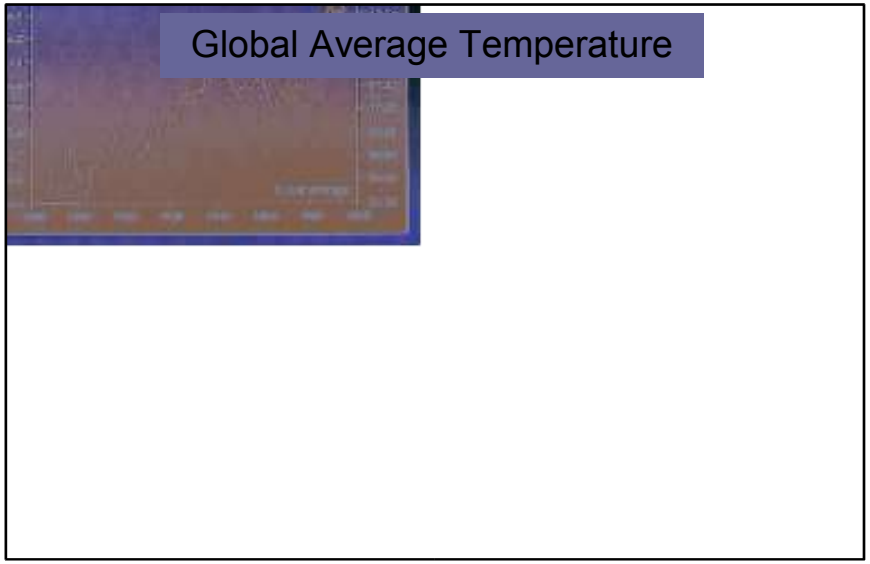
Outline

- The Problem
- The Context
- Proposed Solution
- ACR Theory
- ACR Design
- Preliminary Results
- Project Objectives

The Problem

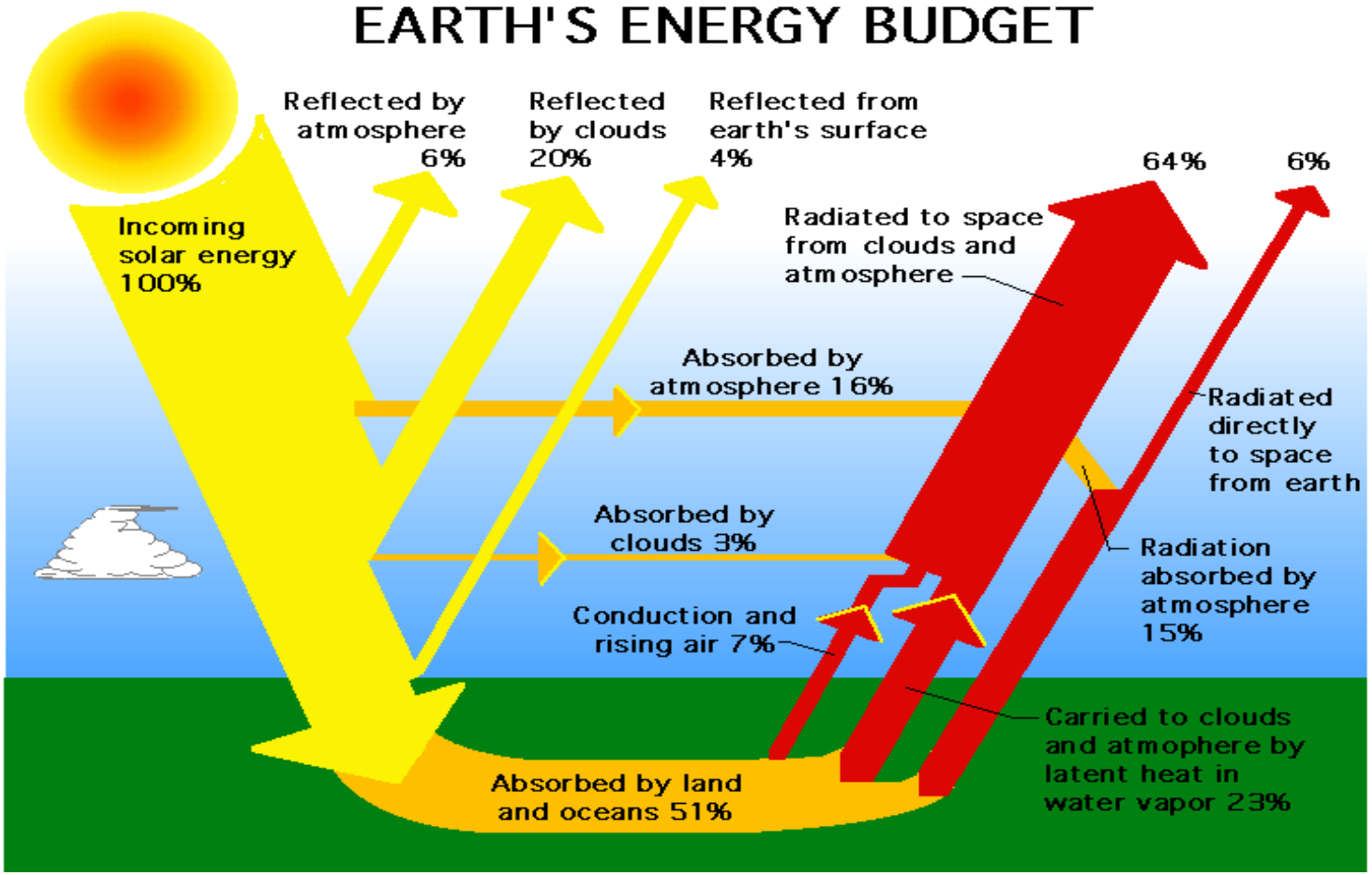
- Need accurate measurements of Earth's radiation for
  - Weather Models
  - Earth Radiation Balance
  - Global Warming Questions



www.whrc.org/globalwarming/ scientificevidence.htm

Global Radiation Balance

- Monitor radiation
- Reduce data uncertainty



asd-www.larc.nasa.gov/people.html/anno/radbud.gif

Earth's Radiation Balance

QuickTime[a] and a
Photo decompressor
are needed to see this picture.

Infrared

Outgoing Long Wave Radiation (5-100 μm) Jan. 2001-Dec. 2002

QuickTime[a] and a
Photo decompressor
are needed to see this picture.

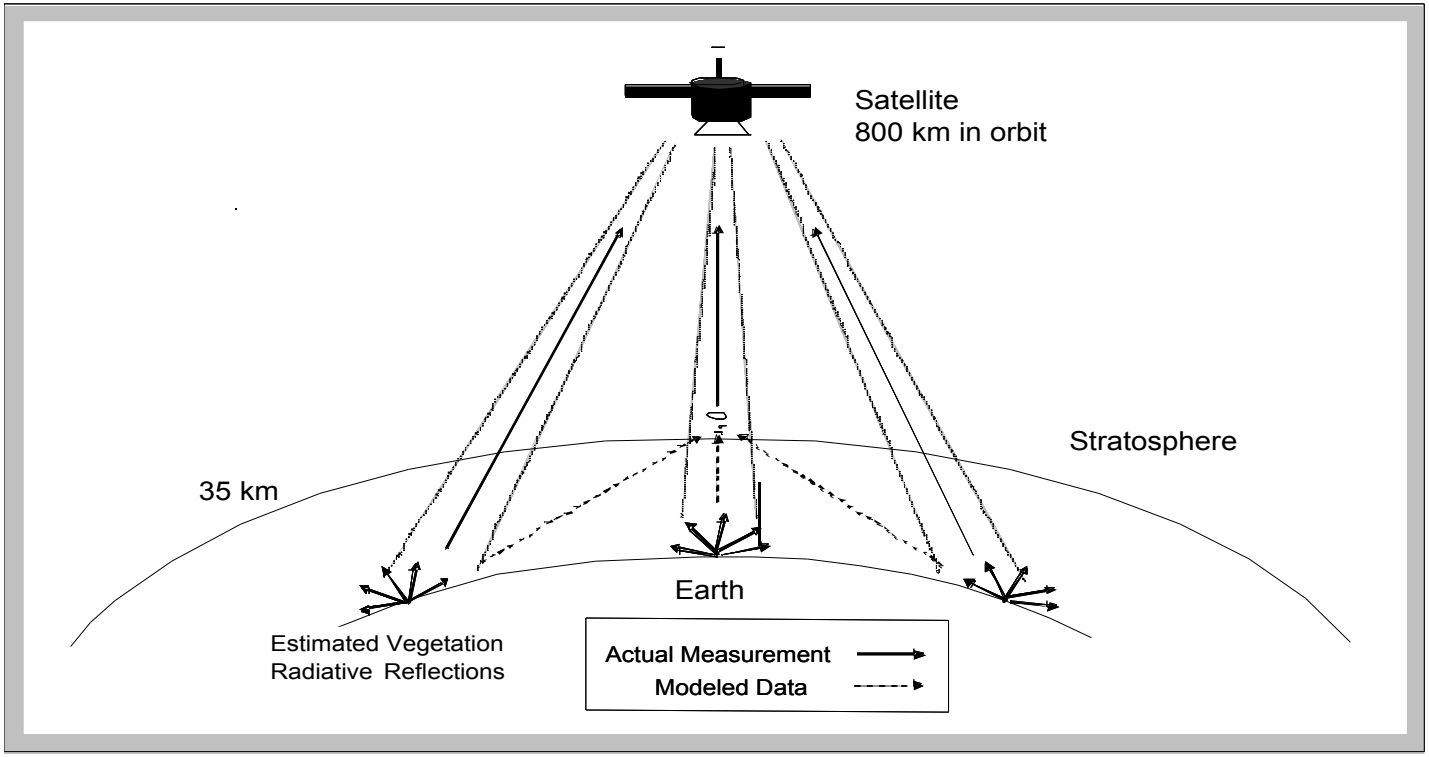
Visible

Outgoing Short Wave Radiation (.3-5 μm) Jan. 2001-Dec. 2002

http://earthobservatory.nasa.gov/Observatory/Datasets/swflux.erbe.html

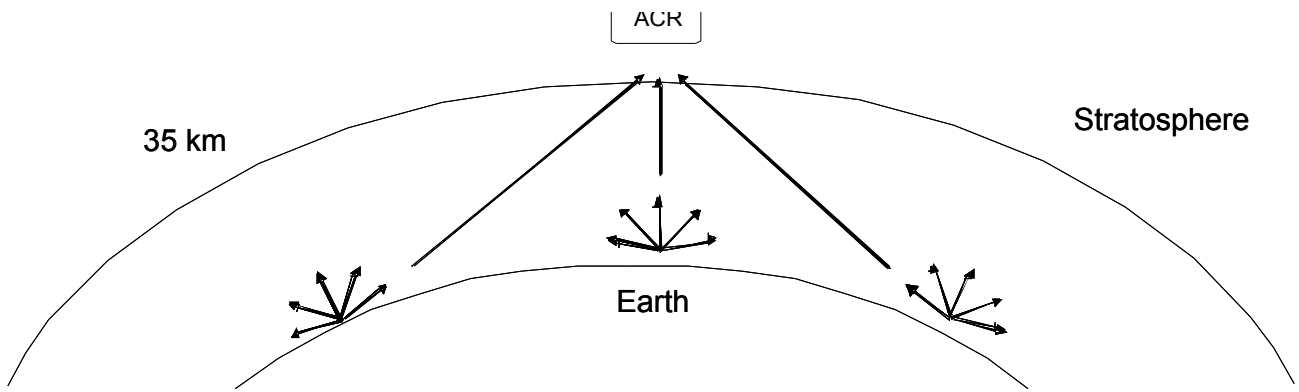
Existing Technology

- Satellite Based Measurements
- Extrapolate to 35 km
- Uncertainty in Results



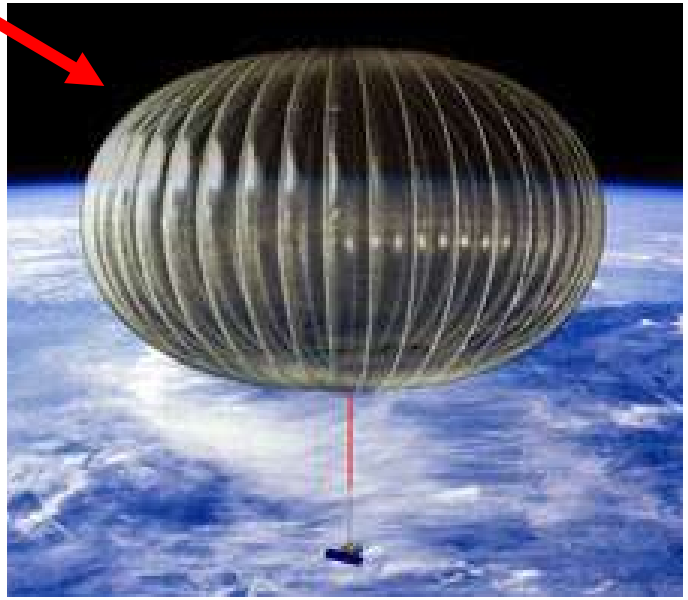
Benefits of Direct Hemispherical Measurements at 35 km

- Reduce sources of modeling uncertainty
- Less modeling of vegetation and albedo
- Ground truth for satellite results



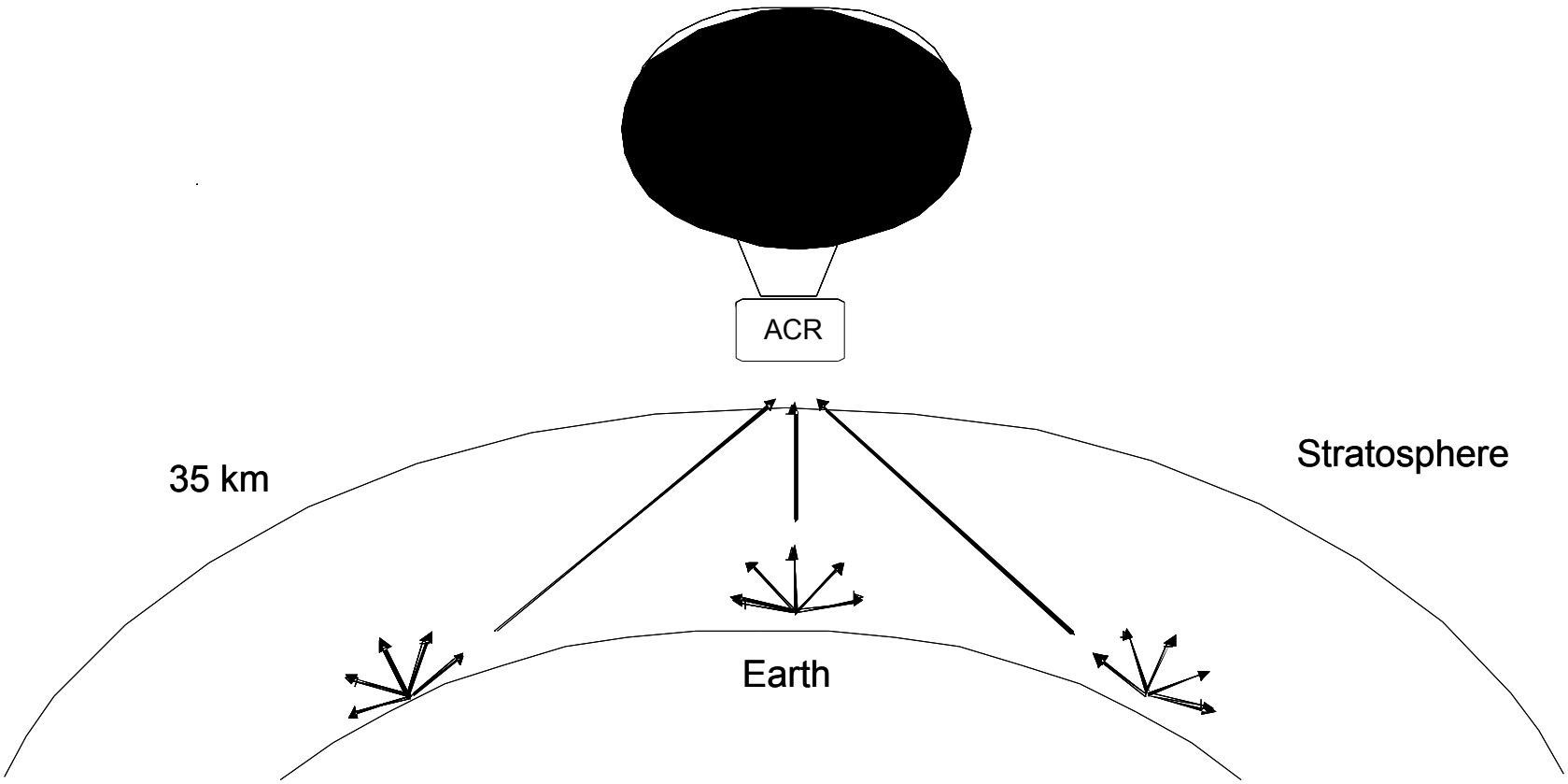
Scientific Balloons Fly at 35 km

- Current Balloon Development
  - NASA flies balloons (<21 days)
  - Under development now
    - Ultra long duration balloons
    - 100 day flights
  - Future
    - 1–10 year flights
    - “Permanent” station at 35 km
- Could Carry ACRs



http://www.gsfc.nasa.gov/goddardnews/20031107/smex.html

ACRs on Stratospheric Scientific Balloons



Possible Future Stratospheric Balloon Networks

- 383 platforms (35 km)
- StratoSail® TCS (20 km)
- Control
  - Biological analog control algorithm
    - 15° to pole
    - Maintain uniform coverage
- 1 year
- 173,000x real time
- UKMO data

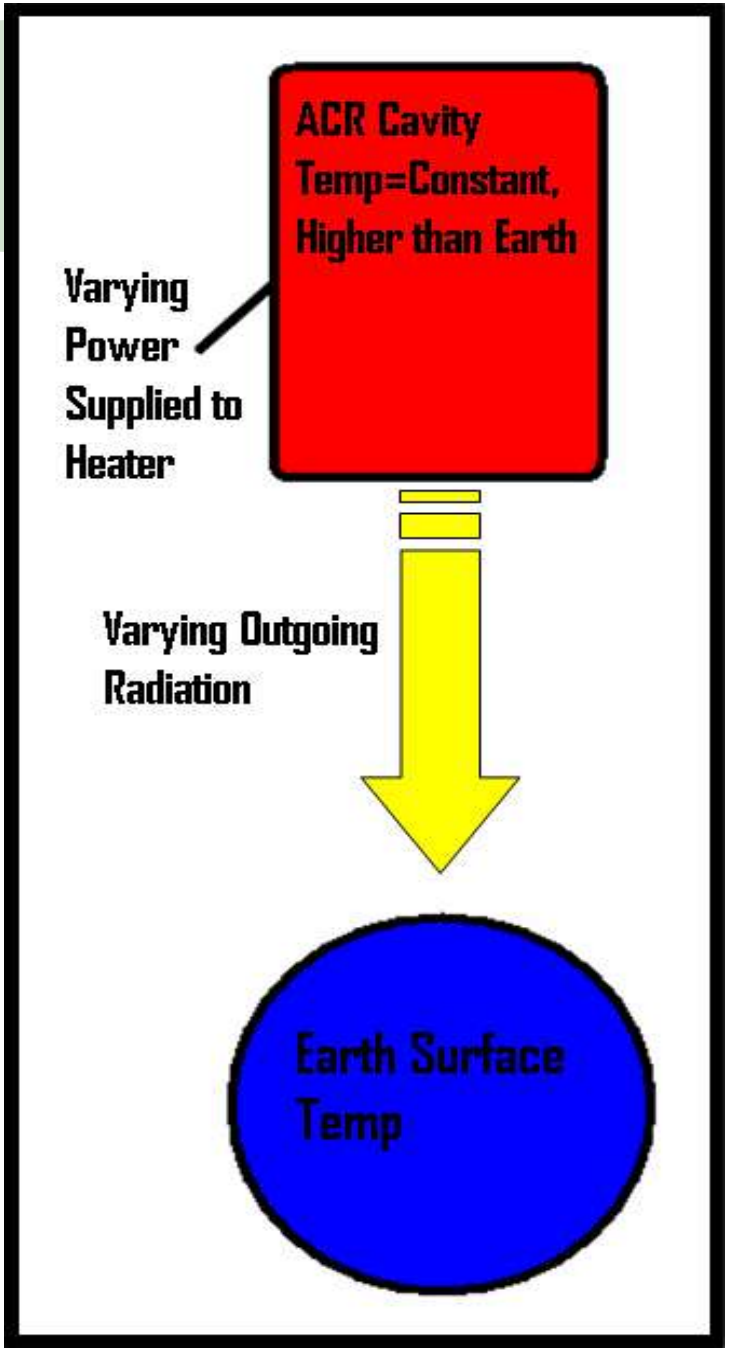
QuickTime[a] and a
Graphics decompressor
are needed to see this picture.

Legend
Red = balloon position
Yellow = 2° elevation angle view zone
Green = zone overlap

Simulation courtesy of
Global Aerospace Corporation

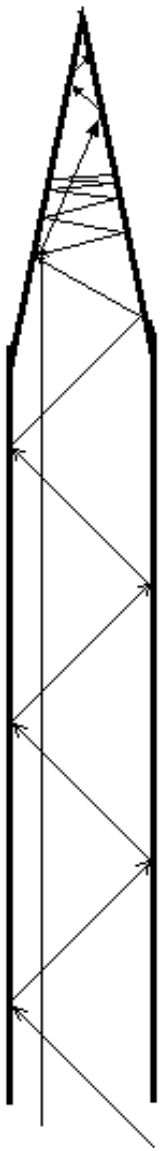
ACR Theory

- Active control of cavity temperature
- Variation of outgoing radiation
  - Warmer scene, less heater power
  - Colder scene, more heater power



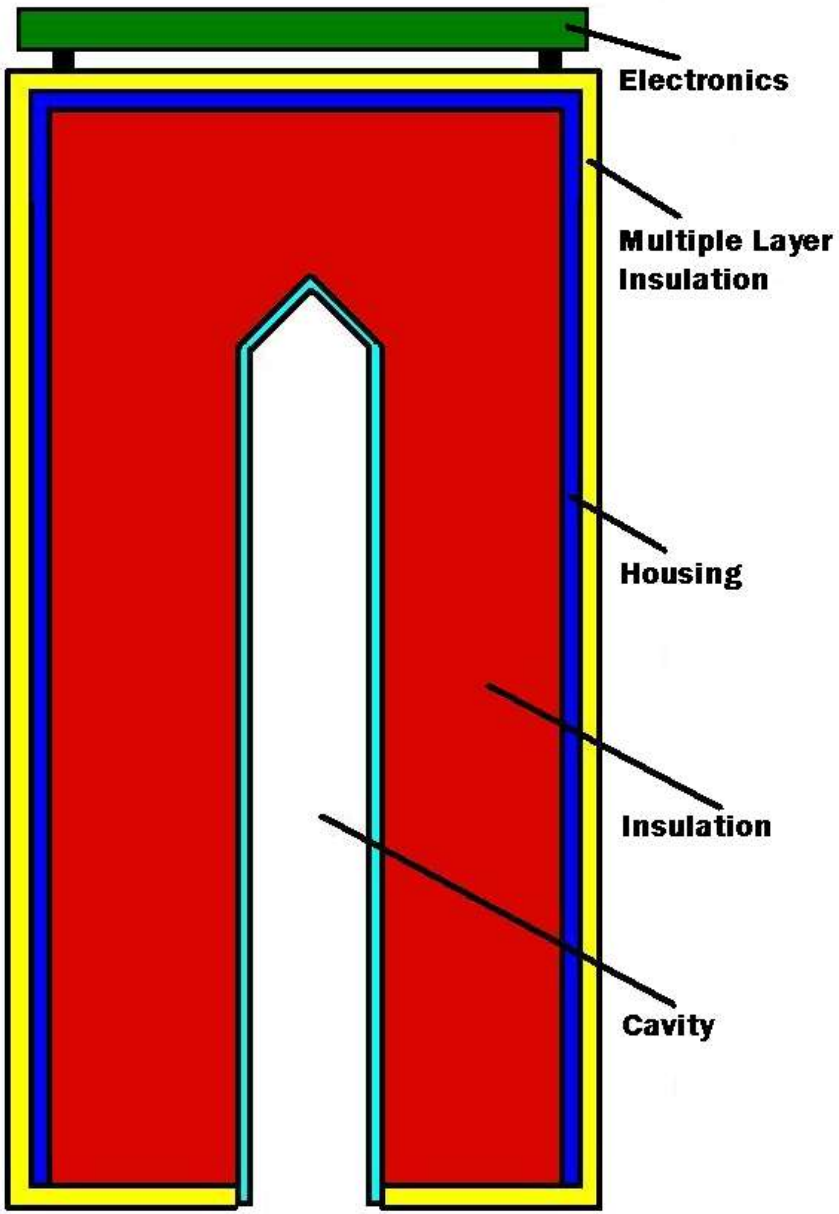
ACR – Internal Reflection

- Cavity Shape Encourages absorption
- Approximates a “Black” Body
  - 100% absorption
  - 100% thermal radiation
  - 0% reflection



ACR Design Issues

- Thermal Management
- Cavity Geometry- size, shape, aperture
- Cavity Temperature Control
- Cavity Calibration



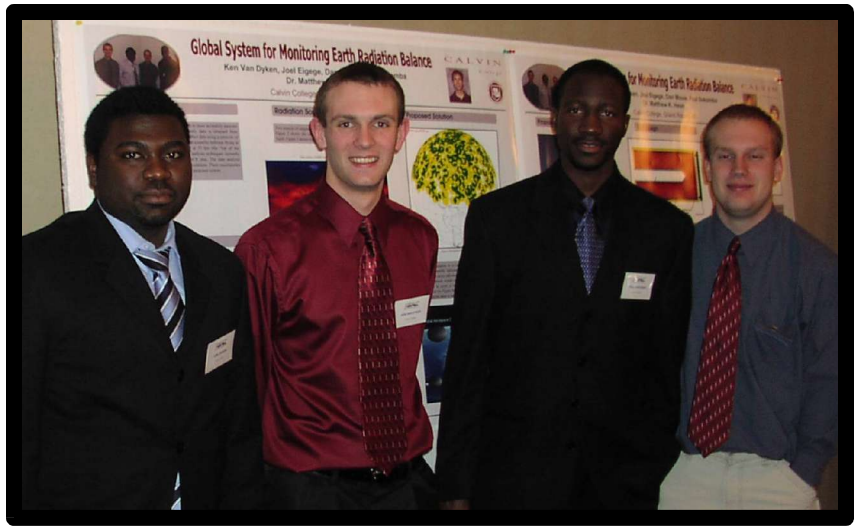
ACR Design- Mechanical Systems

- Cavity geometry design
- Thermal Management
  - Cavity temperature control
  - Cavity temperature distribution
- Weather balloon interface

ACR Design- Electrical Systems

- Power and heater system
- Feedback system
  - Digital or analog
  - PI, PID, or other servo mechanism
- A/D and data storage
- Data transmission

Continuing Calvin College Senior Design Project



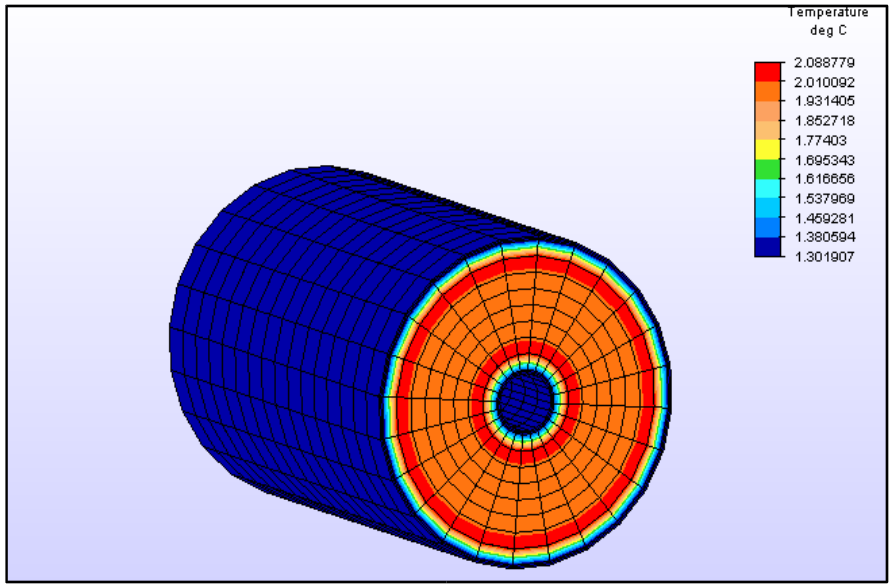
- Initial Project Development

  (03-04)
  - Project Proposal
  - Demonstration ACR Prototype

- Project Continuation (04-05)
  - Finalize ACR Prototype Design
  - Demonstration of Concept Balloon Flight

Initial Project Development (03-04)

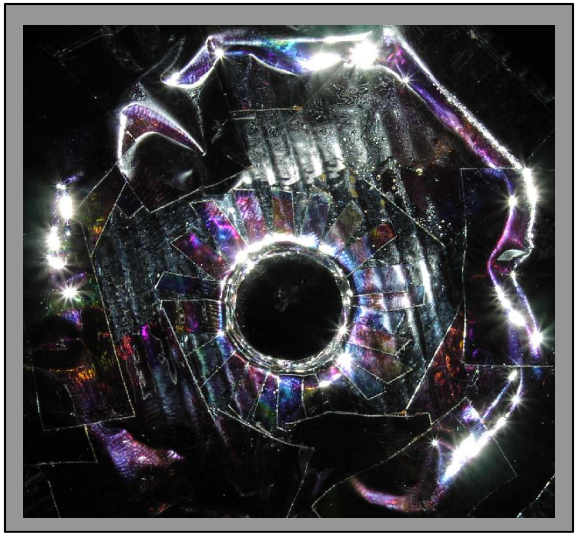
- Thermal Model for cylindrical cavity design
  - Algor© Finite Element Model
  - Numerical Model of Thermo-Electric System



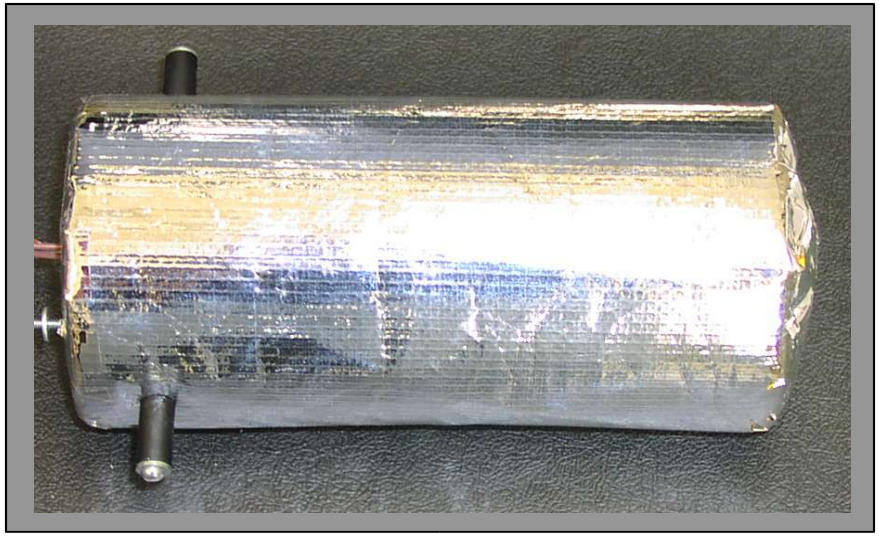
Algor© Thermal Model

03-04 Prototype Development

- Implementation of PID temperature control
- Prototype ACR constructed

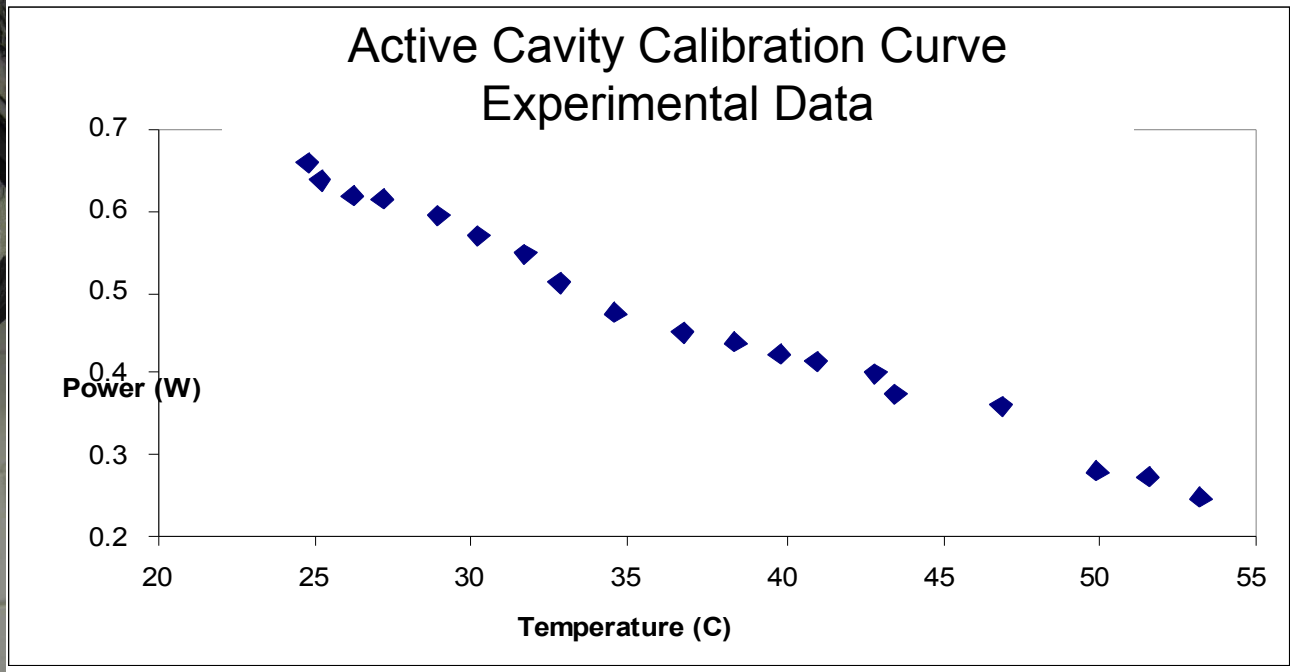


Cavity Aperture



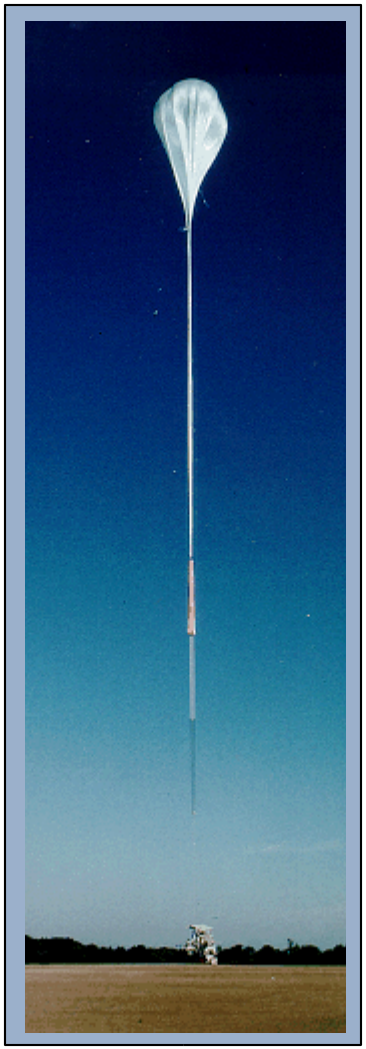
Cavity Side Profile

Prototype Calibration



2004-05 ACR Objectives

- Thermal redesign of ACR cavity
- Electrical controls finalization
- Construct flight ACR's
- Interface mech/elect with weather balloon radiosonde
- Demonstration of concept balloon flight with weather balloon

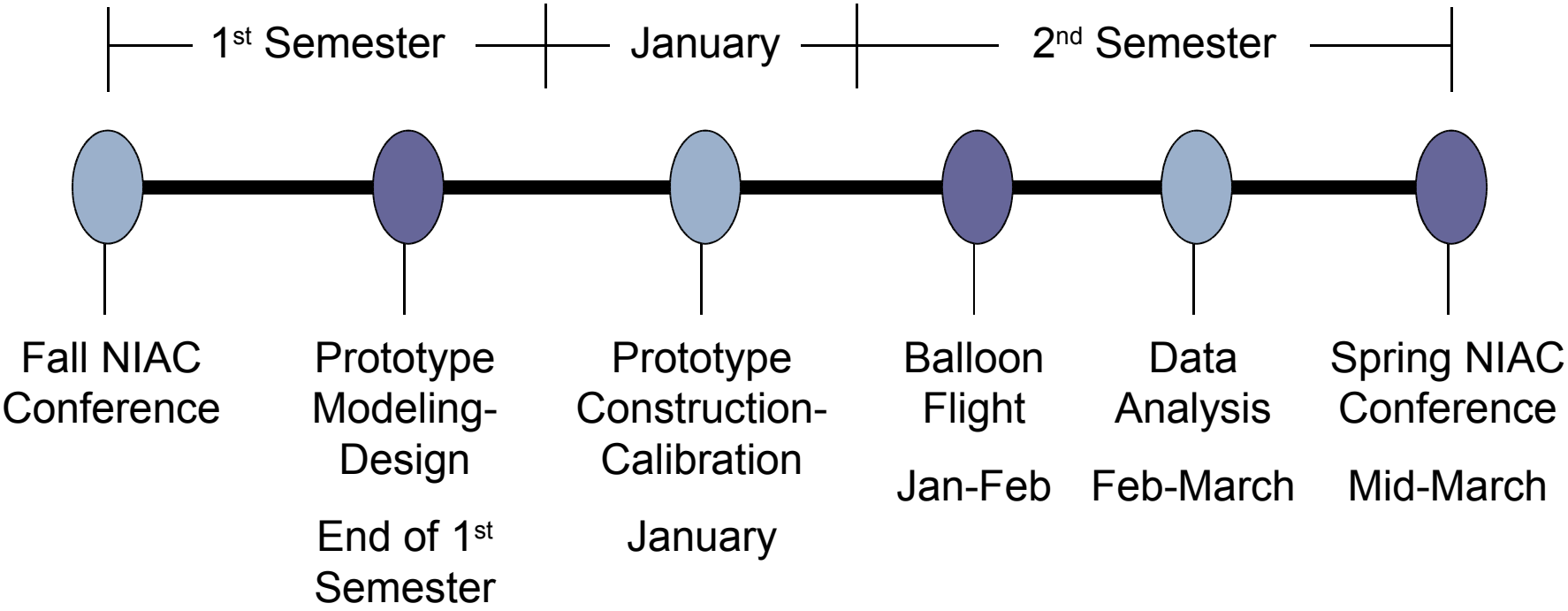


www.rsmas.miami.edu/ rccl/balloon.html

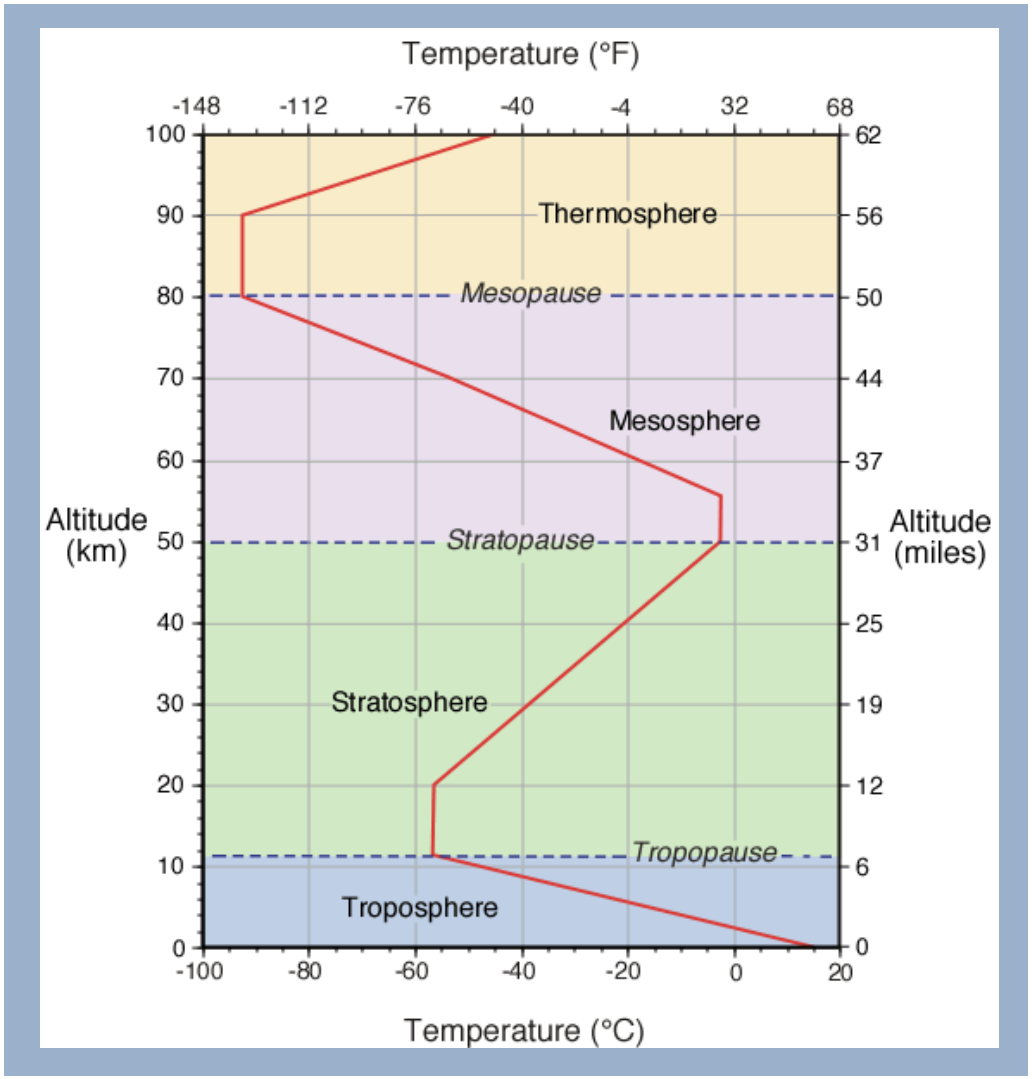
Design Comparison

	2003-04	2004-05
Mass	0.67 kg	< 0.5 kg
Surface Density	-	3 oz/in^2
Power Consumption	< 1.0 W	< 0.5 W
Power Source	AC line	Battery
Environment Temp	300 K	>240 K
Altitude	0 m	0–25 km

2004–2005 Schedule



Questions?

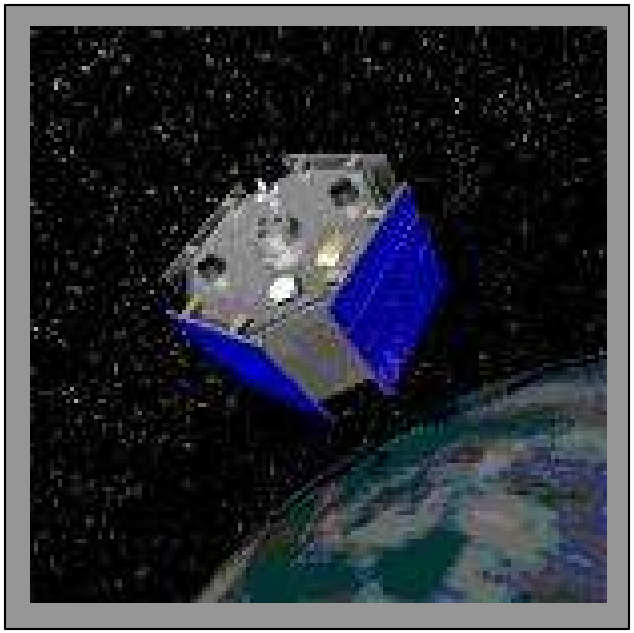

Temperature (°F)
-148
-112
-76
-40
-4
32
68
100
90
80
70
60
50
40
30
20
10
0
62
56
50
44
37
31
25
19
12
6
0
Altitude (km)
Altitude (miles)
Thermosphere
Mesopause
Mesosphere
Stratopause
Stratosphere
Tropopause
Troposphere
-100
-80
-60
-40
-20
0
20
Temperature (°C)

Appendix

Proposed Solution

- Radiation Measurement

ACR



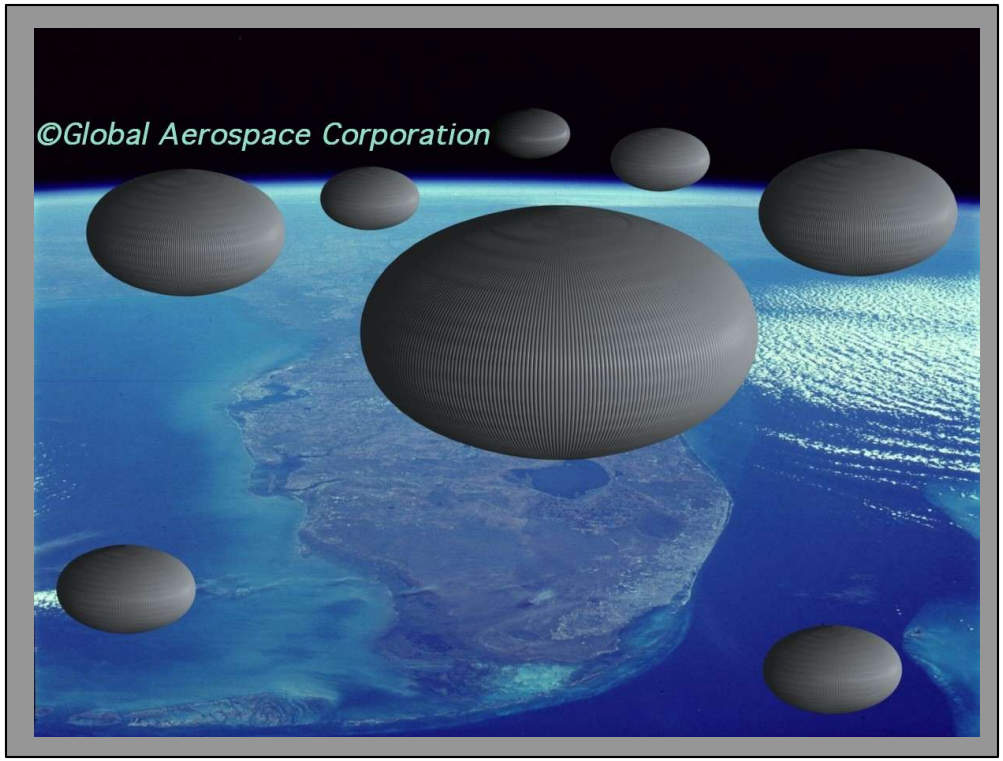
Satellite

vs.

Scientific Balloon

Proposed Solution

- Radiation Measurement
  - Active Cavity Radiometer (ACR)



Global areospace html link here

Educational Context

- Calvin College
  - Senior Design Course