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

**EARTH'S ENERGY BUDGET**

- Incoming solar energy: 100%
  - Reflected by atmosphere: 6%
  - Reflected by clouds: 20%
  - Reflected from earth's surface: 4%
  - Absorbed by atmosphere: 16%
  - Absorbed by clouds: 3%
  - Conduction and rising air: 7%

- Radiated to space from clouds and atmosphere: 64%
- Radiated directly to space from earth: 6%
- Radiation absorbed by atmosphere: 15%

- Absorbed by land and oceans: 51%
- Carried to clouds and atmosphere by latent heat in water vapor: 23%
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

Simulation courtesy of Global Aerospace Corporation

Legend
Red = balloon position
Yellow = 2° elevation angle view zone
Green = zone overlap
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
03-04 Prototype Development

- Implementation of PID temperature control
- Prototype ACR constructed
Prototype Calibration

Active Cavity Calibration Curve

Experimental Data
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

[Image: www.rsmas.miami.edu/rccl/balloon.html]
## Design Comparison

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<th>2003-04</th>
<th>2004-05</th>
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<tbody>
<tr>
<td>Mass</td>
<td>0.67 kg</td>
<td>&lt; 0.5 kg</td>
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<tr>
<td>Surface Density</td>
<td>-</td>
<td>3 oz/in²</td>
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<tr>
<td>Power Consumption</td>
<td>&lt; 1.0 W</td>
<td>&lt; 0.5 W</td>
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<tr>
<td>Power Source</td>
<td>AC line</td>
<td>Battery</td>
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<tr>
<td>Environment Temp</td>
<td>300 K</td>
<td>&gt;240 K</td>
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<tr>
<td>Altitude</td>
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<td>0–25 km</td>
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2004–2005 Schedule

1st Semester

Fall NIAC Conference
Prototype Modeling-Design
End of 1st Semester

January

Prototype Construction-Calibration

2nd Semester

Balloon Flight
Jan-Feb

Data Analysis
Feb-March

Spring NIAC Conference
Mid-March
Questions?
Appendix
Proposed Solution

- Radiation Measurement

ACR vs.

Satellite vs. Scientific Balloon
Proposed Solution

- Radiation Measurement
  - Active Cavity Radiometer (ACR)

Global aerospace html link here
Educational Context

- Calvin College
  - Senior Design Course