

A Vigorous Space Program Based on Climate Control

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Jerome Pearson
STAR, Inc.
Mount Pleasant, SC, USA
www.star-tech-inc.com

1996 Fred Espensk

www.mrecipse.com



Why Go Into Space?

"Acceptable" Reasons

- National Security
- Scientific Discovery
- Economic Benefit

"Real" Reasons

- Conquer New Frontiers
- Explore The Unknown
- Competition and Curiosity

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Our Current Space Crisis

Danger:

- Space may become irrelevant
- Focus on global warming, environment, closed world

Opportunity:

- Space enterprise solves these problems and more
- We can fulfill our visions for space

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New Paradigm: Global Warming

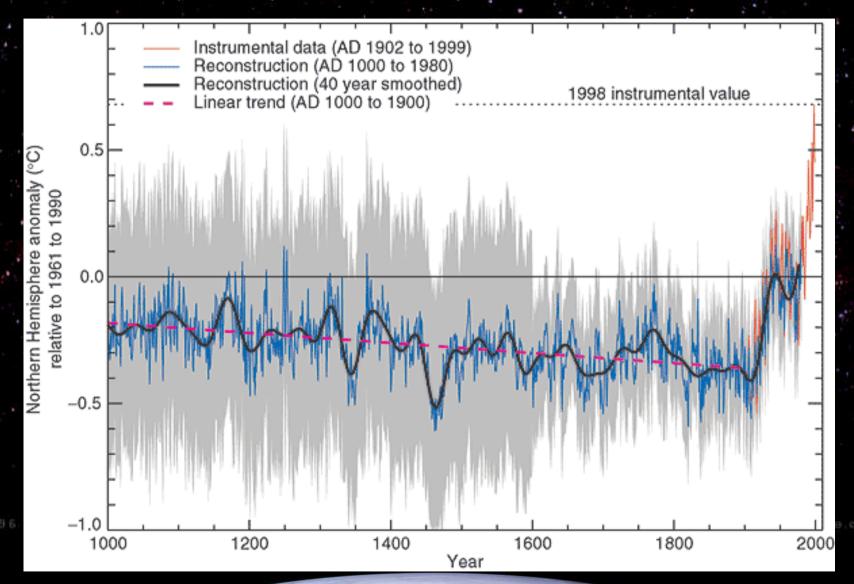
- It Strikes a Chord in us All
 - Dire Predictions of Coming Catastrophes
 - Could Threaten our Entire Civilization

- It Will Command World Resources and Attention
 - US, Europe, UN Already Engaged
 - Programs of Emission Control will last for Decades



The "Hockey Stick" Crisis







A Longer View

- Earth history didn't start 1000 years ago, or even with the current ice age
 - Geological history is known for hundreds of millions of years

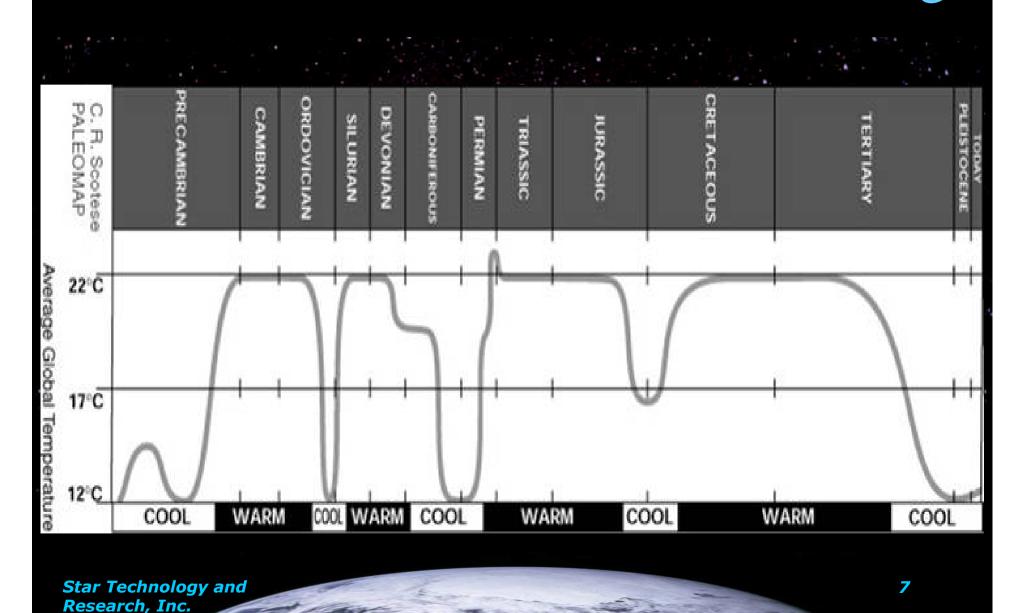
- Geologists know the Earth's temperature history, which says that:
 - Our current ice age is NOT the normal state of the Earth!

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The Earth is Cool, but Warming





The Real Problem

- 1. The Cambrian "explosion" of new forms of life came about during a cold period
- 2. Humans evolved during the current cold period
- 3. When Earth warms again, all our seaport cities will be flooded

Bottom line: we need to maintain Earth in an ice age, which is not its normal state

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The Galaxy May Cause Ice Ages

Time for one Revolution: $226 \pm 12 \text{ MYr}$

Time between Arm crossings: 135 ± 25 MYr

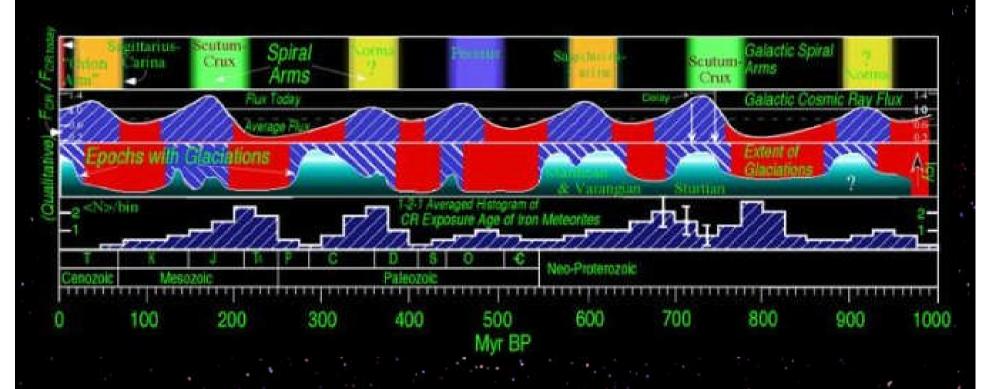
Galaxy Rotation

Sun



Spiral Arms and Ice Ages

(Nir Shaviv and Ján Veizer, 1999)





What Can We Do?

- Limiting greenhouse gas emissions will fail
 - We know that humans did not cause past global warmings, and perhaps not even the current warming

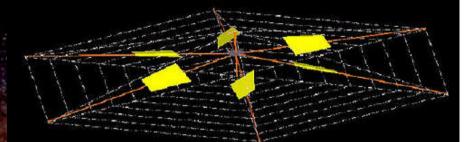
- Two solutions that can succeed:
 - Control the amount of solar energy that reaches Earth
 - Control the amount of energy absorbed by the Earth



Three Workable Solutions



Inject Reflecting Particles



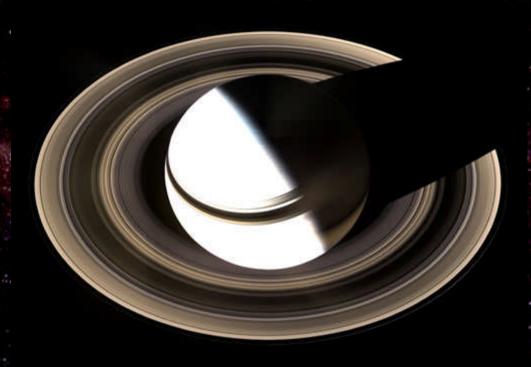
Refract Sunlight at L1



Put "Sunshades" on the Earth



A Beautiful Solution



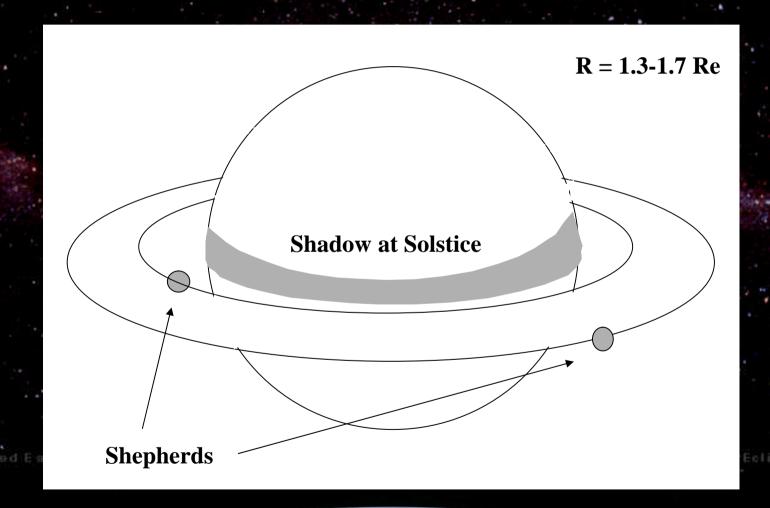
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Saturn from Cassini



Earth Rings for Climate Control

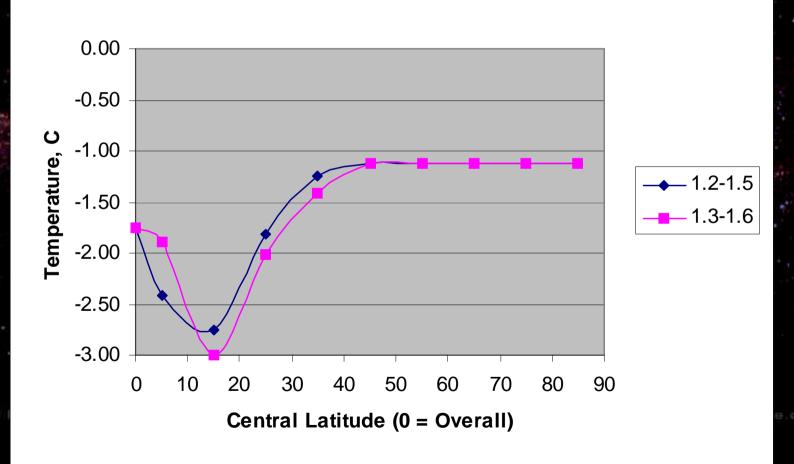
(Pearson et al., 2002, 2006)





Ring Cooling Effect

Temperatures by Latitude Bands





Particle Rings Cause Night Light



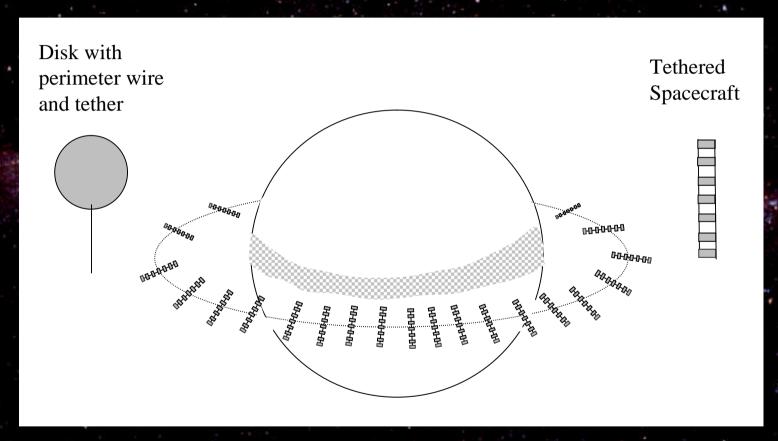
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Saturn from Voyager 1

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Spacecraft Ring Solution



1.6% sunlight shading needed for 1.75 K temperature reduction



Earth-Orbit Satellite Rings

Advantages

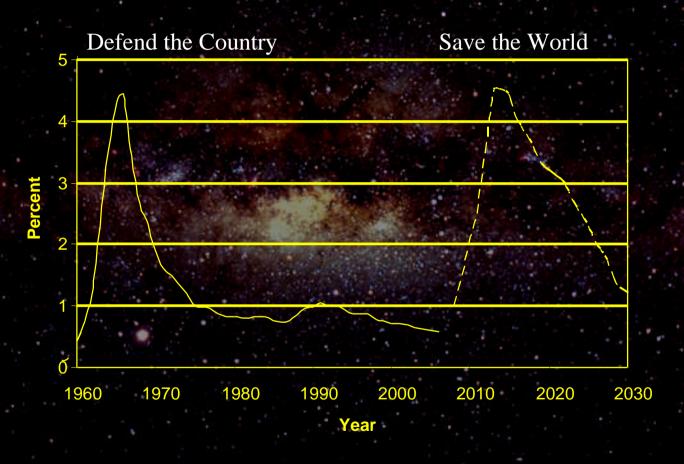
- Stable orbits
- Can provide solar power from space
- Easier to use Moon and asteroid resources
- Builds enormous Earth-to-orbit transport capability
- Does not endanger our industrial capabilities

Requirements

- A sustained, multi-decade program
- A larger project than the Pyramids or the Panama Canal
- World agreement on "planetary engineering"



A New Rationale for Space



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The Choice

1. Reduce human-caused warming only, by spending trillions of dollars and not solving the problem,

or

2. Invigorate our space program to take charge of this planet and put a thermostat on it!

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