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Earth rings for planetary environment control

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Abstract

An artificial planetary ring about the Earth, composed of passive particles or controlled spacecraft with parasols, is proposed to reduce global warming. A flat ring from 1.2 to 1.6 Earth radii would shade mainly the tropics, moderating climate extremes, and counteract global warming. A preliminary design of the ring is developed, and a one-dimensional climate model is used to evaluate its performance. Earth, lunar, and asteroidal material sources are compared to determine the costs of the particle ring and the spacecraft ring. Environmental concerns and effects on existing satellites in Earth orbit are addressed. The particle ring endangers LEO satellites, is limited to cooling only, and lights the night many times as bright as the full moon. It would cost an estimated $6–200 trillion. The ring of controlled satellites with reflectors has other attractive uses, and would cost an estimated $125–500 billion.

Keywords: Artificial planetary rings; Climate control; Global warming; Greenhouse effect; Asteroid materials; Lunar resources

1. Introduction

For 95% of its past, the Earth's climate has been warmer than it is now, with high sea levels and no glaciers [1]. This warmer environment was interrupted 570, 280, and 3 million years ago with periods of glaciation that covered temperate regions with thick ice for millions of years. At the end of the current ice age, a warmer climate could flood coastal cities, even without human-caused global warming. In addition, asteroids bombard the Earth periodically, with impacts large enough to destroy most life on Earth. A recent world concern is the effect of industrial greenhouse gases in raising the overall global temperature, melting the polar caps, and raising sea level. Govindasamy et al. [2] estimated that the expected doubling of CO_2 in the atmosphere over the next century will warm the Earth by about 1–4 K and raise sea level by about 1 m. Not all scientists are convinced of human-caused global warming, but the temperature will rise, regardless of human action, as the world comes out of the current ice age. Reducing solar insolation by ∼1.6% should overcome a 1.75 K temperature rise. This might be accomplished by a variety of terrestrial or space systems. Teller et al. [3] provide an excellent review of the basic physics of a whole range of climate control techniques, with first-order

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Table 1
Summary of climate control methods

Author	Description	Requirements	Mass (kg)	Maintenance
Earth-atmosphere methods				
Dyson and Marland [4]	SO_2 from coal-fired plants	Smokestack additives		Exhaust control required
Brady [5]	Al from rockets	Rocket design		Rocket control
Teller et al. [3]	H_2-filled Al balloons	0.02 μm walls; "anti-greenhouses"	10^8	Replenish as necessary
Earth orbit systems				
Mautner [6]	Saturn-like particle rings	$R = 1.2–1.5 R_E$	3.4×10^{11}	Replenish as necessary
Pearson et al. [8]		$R = 1.3–1.6 R_E$	2.1×10^{14} 2.3×10^{12}	
NAS [9]	Orbiting mirrors in random LEO orbits	55,000 mirrors, $A = 100\,km^2$		Uncontrolled; collisions, debris
Pearson et al. [8]	Controlled spacecraft	50,000 to 5 million spacecraft	5×10^9	Active control
Solar orbit systems				
Early [9]	L_1 lunar glass from mass driver	$D = 2000\,km$, 10 μm thick	10^{11}	Active control
Mautner [6]				
Mautner and Parks [10]	L_1 thin-films	31,000 solar sails, $3 \times 10^{12}\,m^2$ each	5×10^{14}	Active control
Hudson [11]	L_1 parasol			Active control
Teller et al. [3]	L_1 metallic scattering	$D = 638\,km$ $T = 600\,Å$	3.4×10^6	Active control
McInnes [12]	L_1 metallic reflector	$D = 3648\,km$	4×10^{11}	Active control
Other concepts				
Korycansky et al. [13]	Move Earth using Kuiper-belt-objects	150-km object; One encounter every 6000 years	10^{19}	Actively moved, low delta-V
Criswell [14]	Lower sun's mass to slow brightening	Remove plasma from magnetic poles	2×10^{28}	Continual spacecraft ops

evaluations of their mass and cost. Table 1 summarizes these and other proposals for climate control and their parameters. They are grouped into Earth-based systems, Earth-orbit systems, and solar-orbit systems at the Earth-sun L1 Lagrangian point.

Scattering devices or reflectors in the stratosphere would avoid the costs of space launching. Dyson and Marland [4] proposed scattering of sunlight by SO_2 from exhaust stacks, and the eruption of Mt. Pinatubo in the Philippines demonstrated this cooling power of such aerosols in the atmosphere by lowering the Earth's temperature ~0.5 K. Brady et al. [5] proposed cooling by adding 0.1 μm-diameter alumina particles to exhaust stacks, or by a special combustor of aluminum powder at high altitude, to loft alumina dust into the stratosphere. Teller et al. suggested tiny hydrogen-filled balloons with diameters of 8 mm and aluminum walls 0.2 μm thick, to float at 25 km altitude and scatter sunlight.

In Earth-orbit-based systems, Mautner [6] proposed a thin film like a belt around the Earth, and rings of grains. The National Academy of Sciences [7] proposed 55,000 orbiting mirrors of $100\,km^2$ area each, aligned horizontally, but in random orbits. Pearson et al. [8] proposed a particle ring and a ring of controlled satellites. The current paper describes both the particle ring and the ring of controlled satellites.

For solar orbit systems, Early [9] proposed placing a shield at the sun-Earth L1 Lagrangian point, about 1.5 million kilometers sunward from the Earth, as a