Chapter 16

NASA and the Environment: Science in a Political Context

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The advent of the Space Age has paralleled the rise of the environmental movement. NASA was born in 1958 and Rachel Carson wrote *Silent Spring* in 1962; that book is generally seen as marking the onset of modern environmentalism.[2] NASA has intersected with the environmental movement—a set of values and interest groups concerned about the need to protect our natural setting for the current and future generations—in many ways over the years. How did NASA do so? How did it evolve an environmental mission? What did it do with that mission? What were the consequences for society—and NASA—of its environmental role? To answer these questions, this paper will discuss two of the most important ways NASA and the environmental movement related.

First, NASA has had direct impacts through the images of Earth taken by Apollo astronauts as well as by satellites in Earth orbit. Those satellite images and theories about Earth as a system evolved into an organized NASA program, initially called Mission To Planet Earth (MTPE), later the Earth Sciences Program. Second, there was an indirect relation through NASA's mission *from* Earth. Comparative planetology came into existence as a new field; learning about other planets stimulated better understanding of Earth.

There are many other issues in the NASA–environment relation, such as space debris and the contamination of other planets, but these two themes—Earth monitoring and comparative planetology—are especially salient in NASA's history, present, and likely future. The first theme focused on the use of space-based remote sensing and became the dominant emphasis in NASA's environmental history.

1. The author wishes to thank NASA for support for this paper's research and also Sara Pesek for research assistance. Ms. Pesek was a Master of Public Administration graduate student at the Maxwell School of Syracuse University.

2. There are those who would date the beginning of the modern environmental movement from an earlier Rachel Carson book, *The Sea Around Us* (1951). *Silent Spring* came out in 1962. Carson worked for the Bureau of Fisheries, which became the National Marine Fisheries Service within NOAA. Personal correspondence, John Cloud, NOAA, to author, 25 September 2006.

There evolved a set of satellites that can be seen as environmental satellites. They are the centerpiece of NASA's mission to Earth. That mission has had an uncertain, somewhat uneasy relationship with other parts of NASA and other agencies. Some people think it is NASA's most societally relevant mission whereas others think it is extraneous to NASA and belongs somewhere else—the National Oceanic and Atmospheric Administration (NOAA) is the usual candidate. Virtually every observer has found it a controversial mission, one in need of high-level policy attention and improvement for the sake of NASA, the nation, and the world.

The second theme, comparative planetology, has indirectly influenced the main debate—a reminder of the fact that Earth is an island home in the vast sea of space and is the only planet (so far) supporting life. NASA's long association with the environmental and Earth sciences has been fruitful but it has also been contested and even tortuous. The history of NASA and its environmental mission is one of science in a political context.

Beginnings in the Apollo Years

In the 1960s, as NASA concentrated on the Moon project and environmentalism emerged as a conscious political and philosophical movement, NASA began to monitor aspects of the environment in the name of an "applications" program, part of NASA's Office of Space Science and Applications (OSSA). Its chief activity was initially weather satellites. Early on, NASA negotiated a relationship with the predecessor of NOAA, the Weather Bureau, such that NASA developed weather satellite technology and then transferred it to the weather forecasting agency for operational use. The weather satellite program was clearly one of the great successes of the 1960s. It was obvious to all that weather satellites improved forecasts and aided early warnings of approaching hurricanes. There was a technology push from NASA and a pull from a user agency.[3]

Comparative planetology also began in the 1960s, with the Mariner spacecraft flybys of Venus and Mars. Venus revealed a runaway greenhouse effect that heated it into an inferno, providing an early example to some scientists of what could happen here. Mars also seemed inhospitable to life. But the most important impacts on the environmental movement of the early space program were pictures of Earth taken by Apollo astronauts, beginning with Apollo 8 in 1968—the Christmas Eve flight around the Moon. For the first time, humanity saw a blue Earth in the desolate blackness of space. As the environmental movement emerged, it used these images

3. Homer Newell, "Space Science and Practical Applications" in *Beyond the Atmosphere: Early Years of Space Science* (Washington, DC: NASA, 1980).

of our planet as a symbol for the first Earth Day in 1970. Without a doubt, the space program helped catalyze the environmental movement, especially insofar as getting it to think about the *global* environment.[4]

NASA in the 1970s

The 1970s are often called an environmental decade. One reason is that Environmental Protection Agency (EPA) was born in 1970 and Congress enacted a sequence of laws to deal with water, air, and other forms of pollution. Another reason was the energy crisis of the decade, and writings on "limits to growth."[5] The Carter administration, in particular, integrated environment and energy conservation and conveyed the notion that "small is beautiful." This notion was applied to technology, which environmentalists argued had to be "appropriate" to the user.[6]

The space program in the 1970s mirrored the decade's political setting. NASA devolved from Apollo, whose Moon flights ended in 1972, to the Space Shuttle. NASA diminished in size and exploratory capacity. The NASA Administrator, James Fletcher, who served from 1972 to 1977 (the first of two terms at NASA's helm) was personally interested in environmental stewardship, a characteristic Launius has linked in part to his Mormon roots. However, the situation he faced was problematic. The environmental movement of the early 1970s had a distinctly anti-technological flavor. It contributed to the termination of the supersonic transport (SST) in 1971. There were concerns in NASA that environmentalists might attack the Space Shuttle as they had attacked SST, on environmental factors. NASA realized that it needed to research environmental-atmospheric impacts of the shuttle to defend itself, if necessary, against possible opposition[7] More positively, Fletcher sought to align his Agency with environmental values. In 1973, he told Congress that NASA should be considered "an environmental agency." He declared: "Everything we do . . . helps in some practical way to improve the environment of our planet and helps us understand the

4. Comparative planetology helped crystallize global warming as an issue. See Spencer Weart, *The Discovery of Global Warming* (Cambridge, MA: Harvard University Press, 2003), pp. 87–89. See also Steven Dick and James Strick, *The Living Universe: NASA and the Development of Astrobiology* (New Brunswick, NJ: Rutgers University Press, 2004); Marina Benjamin, *Rocket Dreams* (New York: Free Press, 2003); and Neil Maher, "Gallery: Shooting the Moon," *Environmental History* (July 2004).

5. *Limits to Growth* was the name of a best-selling book authored by Donella Meadows and others and published in 1972 under the auspices of a business group called the Club of Rome. It modeled the consequences of a world with a growing population and limited resources. It was republished in 2002 by Chelsea Green Publishing, White River Junction, Vermont.

6. For views of appropriate technology, see E. F. Schumacher, "Buddhist Economics," and Paul Goodman, "Can Technology be Humane?" in *Technology and the Future*, 7th ed., Albert Teich, ed. (New York: St. Martin's Press, 1997).

7. Kim McQuaid illuminates NASA's early ambivalence about environmentalism in "Selling the Space Age: NASA and Earth's Environment, 1958–90," *Environment and History* 12 (2006), pp. 127–163.

forces that affect it. Perhaps that is our essential task, to study and understand the Earth and its environment."[8]

Fletcher promoted a new Earth-oriented satellite, called Landsat, launched in 1972, that was capable of helping to forecast world food harvests and other resource issues. Conscious of environmentalist concern about pollution of the stratosphere from high-flying planes that could extend to the shuttle, he sought legislation to undergird NASA's emergent environmental (and shuttle) interests. In 1975 Congress authorized NASA "to conduct a comprehensive program of research, technology, and monitoring of the phenomena of the upper atmosphere." In 1977, Congress required NASA to issue biennial reports to Congress on the status of ozone depletion, an issue beginning to worry some scientists and environmentalists. This legislation (1975 and 1977) was important; it gave NASA legitimacy not only to do environmental research but also to link it with policy.[9] It was not a "given" that NASA would have this mission rather than another agency. It reflected NASA's administrative entrepreneurship and Congressional support relative to that of potential rivals.

The 1970s also featured the growth of comparative planetology, as a field, energized by the 1976 Viking mission to Mars and James Lovelock's Gaia Hypothesis. Lovelock, who published his ideas in 1974, held that Earth was a living system in which physical and biological components worked together to enable life. As it developed, the Gaia Hypothesis drew on studies of other planets, including Viking's apparent failure to find life on Mars. It made a number of scientists and environmentalists better appreciate Earth as a precious and vulnerable home and the role of human beings in altering it. There even were those such as Gerard O'Neill, a Princeton physicist, who speculated that man might need to migrate beyond Earth and establish colonies in space—a new, better place, a utopia where a more eco-friendly existence could be practiced.[10]

The Rise of NASA's Environmental Role in the 1980s

The 1970s produced a set of ideas about Earth as an interacting system. Also, some scientists felt that techniques used to study Mars could be applied on Earth.[11] The decade also gave rise to NASA's thinking more strategically about crafting an

8. Roger Launius, "A Western Mormon in Washington, DC: James C. Fletcher, NASA and the Final Frontier," *Pacific Historical Review* (1995), p. 236.

9. W. Henry Lambright, *NASA and the Environment: The Case of Ozone Depletion* (Washington, DC: NASA, 2005), pp. 7–8.

10. Dick and Strick, p. 49; Benjamin, pp. 51, 121–138.

11. In 1976, when NASA sent Viking to Mars, it found the intended landing spot to be unsuitable. NASA and leading Mars specialists searched for three weeks to find a good place, surveying virtually the entire planet. At the end, Michael McElroy of Harvard declared: "You know, we've never done anything like this for the Earth." Burton Edelson, "Mission to Planet Earth," *Science*, 227, no. 4185 (25 January 1985), p. 6.

environmental mission and how better to use the legislation it had obtained for its atmospheric research. In the 1980s, NASA charted a larger and broader Earth observation program that built on its work in weather, land satellite monitoring, and initial attempts at ocean surveys. What NASA contributed, through its satellites and comparative planetology studies, was a perspective different in scale from other agencies—literally a global view. There were certain environmental issues that were indeed global in scale and NASA, in the view of some of its officials and external supporters, was particularly suited to address these.

In 1982, NASA Administrator James Beggs, responding to overtures from OSSA, went to the United Nations Conference on the Peaceful Uses of Outer Space, where he called for "an international cooperative project to use space technology to address natural and manmade changes affecting habitability of Earth." The reaction to his "Global Habitability" overture was overwhelmingly negative—not to the idea of global habitability but to NASA as leader. "It came across like NASA was trying to take over the world," Burton Edelson, associate administrator of OSSA, recalled.[12] There had been no spadework ahead of time to build a coalition of support for the proposed endeavor. Beggs told Edelson to build that support base with other agencies, the White House, the scientific community, and the public before surfacing the proposal again.

This he began to do, starting in 1983 with a broad-gauged Earth System Science Committee. Edelson worked outside and inside NASA—outside with the scientific community, the National Science Foundation (NSF), and the National Oceanic and Atmospheric Administration (NOAA) in particular, and inside by establishing an Earth Sciences and Applications Division within OSSA to augment the Earth science personnel and presence within NASA. In 1985, Edelson wrote an editorial in *Science* magazine. Dropping the "Global Habitability" name, he proclaimed the need for a new "Mission To Planet Earth."[13] While this planning and support-building was underway, events provided NASA an opportunity to demonstrate how it could lead in a new global environmental mission.

The issue was ozone depletion. It had risen and declined as an issue in the 1970s but in the mid-1980s had returned with a vengeance. In 1985, British scientists using ground-based studies discovered extraordinary and shocking ozone depletion over Antarctica. NASA quickly followed-up with satellite observations confirming what became known as the "ozone hole."[14]

The media, using NASA satellite images, conveyed an eerie and graphic display of a gigantic hole that seemed to grow like an organism over Antarctica. The images alarmed the public, as they were accompanied with reports of how skin cancer could be caused by ozone depletion if the hole spread to more populated places. Scientists,

12. W. Henry Lambright, "Entrepreneurship and Space Technology: The Ups and Downs of 'Mission to Planet Earth,'" *Public Administration Review* (March/April 1994), pp. 97–104.

13. Edelson, "Mission To Planet Earth."

14. Lambright, *NASA and the Environment*.

media, environmentalists and politicians sounded the alarm. Industry defended itself against over-hasty regulations, but was on the defensive.

NASA seized the initiative. It had the legislation from the 1970s that gave it legitimacy to take a "lead agency" role on the science side of this issue. It organized a scientific expedition to Antarctica. Enlisting NOAA, NSF, academic scientists from the United States and abroad, and even industry researchers, NASA and its allies sought to determine the cause of the hole. Robert Watson, an energetic OSSA manager, was the prime mover in the Antarctic expedition. He struck a close alliance with a key scientist-administrator of NOAA, Dan Albritton, and practiced what Albritton called "ecumenical" leadership. One Antarctic expedition was soon followed by another, more extensive one. It became increasingly clear to the scientists that the prime suspects behind the hole were common chemicals called chlorofluorocarbons, or CFCs, found in a host of everyday products. This growing consensus extended to industry scientists involved in the expedition and was endorsed by an independent group of scientists Watson set up to review the expeditions' findings.

Watson and Albritton played dual roles—scientist-administrators of two agencies collaborating in an ad hoc program to determine causality in ozone depletion, and science advisors to the State Department and the EPA. These "policy agencies" were users, in real time, of information from the science agencies. There was again a push and pull on the part of providers and users. The technical information—what was known and what was not known—was conveyed to diplomats in the field. The diplomats were meeting under international political pressure to act, and did so in 1987, producing the pathbreaking Montreal Protocol, an agreement which set deadlines for replacing CFCs with less harmful chemicals. The Montreal Protocol was remarkable in calling for amendments as science produced more precise knowledge. Ozone depletion in many ways became the model for subsequent international environmental policy.

It was also seen as a potential model for NASA. NASA leaders contemplated ozone depletion as the first step in the broader global environmental initiative it had sought since 1982. The ozone experience, highly positive for NASA in a public relations sense, took place in a period when the Agency otherwise suffered severe criticism for the *Challenger* Space Shuttle disaster. That disaster, in 1986, had brought James Fletcher back to the Agency. While presiding over NASA's return to flight, he also looked ahead to new missions. He asked Sally Ride, America's first woman in space, to study possible initiatives beyond the space station, NASA's existing flagship project, that would give long-term direction to the Agency. Her 1987 report listed four options, without giving any priority. The first she listed, however, was a Mission To Planet Earth. Calling the mission of "fundamental importance to humanity's future," Ride said NASA was "uniquely suited to lead the effort." In the wake of the ozone experience, NASA was now in a far better position to make the case politically for a new mission than it had been in 1982.[15]

15. Lambright, "Entrepreneurship and Space Technology."

Achieving Policy Adoption

Advocates of the new mission, largely in OSSA, began pushing harder for policy adoption of a new program. Drawing on the work of the Earth System Science Committee, which completed its studies in 1986, NASA set as the new program's centerpiece an Earth Observation System (EOS). EOS would feature two 13-ton, bus-sized platforms launched by the Space Shuttle and linked with the Space Station *Freedom*. They would have multiple sensors, enough to permit comprehensive and simultaneous views of land, atmosphere, and sea interactions. The estimated cost of a system that delivered 15 years of observations was $30 billion. The full system would be launched by 2001. A series of specialized "precursory" missions in the 1990s would lead up to the main event, an operational two-platform EOS replete with an unprecedented data-handling and disbursing system. The EOS vision included potential additional systems contributed by other nations.

A program this big could only be justified if applied to a very big problem. The problem that had emerged over the 1980s in parallel with EOS planning was called "global change." Global change included, but was not limited to, climate change. Climate change was a politically neutral way of referring to global warming. Global warming was controversial among scientists and even more so among politicians. Climate change was a much more complicated problem than ozone, both scientifically and politically. Climate change had even been connected with scientific opposition to the Reagan administration's nuclear weapons policy. Scientists, led by space scientist Carl Sagan, warned against a "nuclear winter" if atomic weapons were ever used. Whether hot or cold, Earth's climate was complex and many scientists felt it premature to forecast a dire future, for whatever reason, given existing understanding. Moreover, there was not an ozone hole to focus scientific work and trigger policy action. Instead, there was a slow accumulation of contentious scientific information. Although NASA's lead role in investigating ozone depletion might be seen by the Agency to be a model for a Mission To Planet Earth, the transfer of the model to climate and global change would not be straightforward. NASA had no special legislation that gave it legitimacy to assert its claims, but at least one man within NASA was asserting his own views.

In 1988, James Hansen, director of NASA's Institute for Space Studies, proclaimed before Congress that global warming was almost certainly a reality now. He declared to reporters afterward that it was time to "stop waffling and say that the evidence is pretty strong that the greenhouse effect is here."[16] His view was not popular with the Reagan White House. The Reagan administration established an interagency committee, whose dominant members were NASA, NOAA, and NSF, to get at the facts. From this committee, initially called Committee on Earth Sciences (CES),

16. Weart, p. 155.

came the proposal for a U.S. Global Change Research Program (USGCRP). When George H. W. Bush became president in 1989, CES had a report waiting for him and his science advisor, Alan Bromley. Bush said he wished to be "the environmental president" and, on the advice of Bromley, made global change his first "presidential priority" in science and technology. Such a designation slated global change for policy adoption and budget support. The USGCRP combined space and ground-based observations. The largest single item in the interagency effort would be EOS, but NASA was not a "lead" agency. Leadership was vested in the USGCRP interagency committee, whose name was broadened, along with its membership, to Committee on Earth and Environmental Sciences (CEES). In 1990, Bush officially adopted Mission To Planet Earth as a NASA priority. Congress provided endorsements and an initial appropriation to start EOS. The advocates of a greater NASA role in global environmental monitoring thereby achieved a victory after almost a decade of planning and strategizing. NASA was poised to use space technology in a grand effort to develop an "Earth System Science." Such a science would pave the way for a "predictive capability" in global change that would guide policy makers, and thereby protect planet Earth.[17]

WOUNDED AT THE OUTSET

In theory, a new government program moves from adoption to implementation, at which point it has the opportunity to show its mettle before later undergoing evaluation and possible mid-course correction. Not so MTPE/EOS. NASA's environmental initiative faced drastic reorientation almost as soon as it got underway, before implementation could commence in a serious way. There were five obstacles to stable growth it confronted in the years of George H. W. Bush. The first was a larger, more compelling national policy imperative concerning the overall federal budget. With the cold war waning and the federal budget deficit soaring, politicians increasingly wanted to cap spending on discretionary programs as much as possible to lower the deficit. This put all "big science" programs in danger, and EOS was clearly big science at a projected $30 billion. The Bush White House and Congress pressed NASA for redesign to lower costs.

OSSA's associate administrator, Len Fisk, argued in 1991 for staying the course in plans and budget. Stating that a "comprehensive" approach was essential, he declared that Earth was "too complicated, and its workings too interrelated" for a piecemeal strategy. "It's a big Earth," he stated. "and there are big consequences for getting the wrong answers."[18] Unfortunately for EOS, there was a second problem: lack

17. Lambright, "Entrepreneurship and Space Technology."

18. Lennard Fisk, "Mission to Planet Earth," address to Maryland Space Business Round Table, 26 February 1991, NASA History Office Files.

of cohesion in support on the part of the scientific-environmentalist constituency. NASA's own Hansen, clearly alarmed about the global warming issue, said that the comprehensive approach of EOS would take too long to show results. While saying he supported EOS, he proposed a short-term, smaller-satellite strategy specifically geared to resolving the climate change debate.[19] The Hansen view was shared by various environmentalists and their prime legislative spokesman, Senator Al Gore (D-Tennessee). Many environmentalists in fact regarded EOS as an administration delaying tactic—researching instead of responding to climate change with emissions controls. At a time when Fisk needed solid backing for EOS, there were fissures in his potential scientific and environmental constituency.

The third problem Fisk faced was that NASA's flagship program, Space Station *Freedom*, was running into serious opposition in Congress. In her 1987 report, Ride had mentioned MTPE as one of four new initiatives that would build on the space station. However, EOS seemed now to be competing with the space station for funds. Both programs would cost billions. Congress told Bush and NASA: prioritize! When Congressional threats to terminate the space station forced Bush and NASA Administrator Richard Truly to choose, they made it clear that the space station was their priority. Congress in 1991 directed NASA to cap EOS expenditures at $11 billion through the year 2000. This was $6 billion less than NASA had projected during the 1990s for the two-platform design. Reorientation of the program became essential.[20]

The fourth obstacle to the program adopted in 1990 came in April 1992, when Dan Goldin arrived as NASA Administrator. By this time, the two-platform design was giving way to a fleet of six satellites, carrying fewer instruments. Goldin removed Fisk and reorganized OSSA into three smaller units. MTPE/EOS survived, but Goldin demanded it adhere to his philosophy of faster, better, cheaper (FBC). He called the original EOS design a "Battlestar Galactica," and even the six-satellite fleet failed his criteria.[21]

The fifth obstacle to implementing the original vision was the end of the relative political bipartisanship that had made adoption of MTPE/EOS possible in the first place. In the view of some conservative Republican lawmakers, NASA became politicized in the early 1990s. Ironically, NASA gave ammunition to its critics. As it shifted emphasis from ozone depletion to global climate change, it continued its ozone work, using the first satellite deployed under the MTPE rubric, the Upper Atmosphere Research Satellite (UARS). The focus of NASA's ozone research moved from the South Pole to the Arctic. NASA researchers in early 1992 detected an Arctic ozone hole opening up and publicly announced that fact with a sense of alarm.

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19. James Hansen et al., "The Missing Data on Global Climate Change," *Issues in Science and Technology,* vii, no. 1 (Fall 1990), pp. 62–69.

20. Lambright, "Entrepreneurship and Space Technology," p. 102.

21. Stephanie Roy, "The Origin of the Smaller, Faster, Cheaper Approach in NASA's Solar System Exploration Program," *Space Policy* 14 (1998), p. 165–167.

Environmentalists, the media, and various legislators demanded action. Senator Gore, whose book, *Earth in the Balance*, came out in 1992, pointed out the danger of an Arctic ozone hole spreading over populated territory in the North. Critics of Bush said that there would soon be an ozone hole over Bush's head in his summer home in Kennebunkport, Maine. Bush did in fact act, using powers he had under domestic legislation related to the Montreal Protocol. He ordered a speed-up in the phasing out of ozone-depleting chemicals. There was thus again a swift progress from science to policy. The only problem this time was that NASA subsequently admitted that it had sounded the alarm prematurely and that there was no Arctic ozone hole. Nor, said a chastened NASA spokesman, was there a hole over Kennebunkport.[22]

The consequence was that conservative lawmakers and media seized the moment to criticize NASA's credibility and link the space agency to the environmentalists' agenda on global warming. As Bush left office, NASA's environmental mission was flayed by critics as politicized, and opposition in Congress loomed.

Thus, in the course of just four years—one presidential administration—NASA's environmental mission went seemingly from a high priority of NASA and the nation, with bipartisan support, to an embattled program struggling to survive, technically and politically.

More Turbulence Under Clinton

The inauguration of Bill Clinton as president, and especially Al Gore as his vice president, in 1993 guaranteed that NASA would continue to have an environmental role. The issue remained one of content and scale. Clinton retained Goldin as NASA Administrator, and NASA's Robert Watson moved up to the White House Office of Science and Technology to a new post of associate director of the Office of Science and Technology Policy (OSTP) for Environment.

The problem for MTPE/EOS was that Clinton, not Gore, was president. Also, both men had many other priorities and were far more interested in environmental action—including CO2 emissions reduction—than a long-term research program like EOS. Moreover, the larger enterprise of which EOS was the centerpiece, USGCRP, continued but lost momentum as a federal coordinating vehicle. The interagency committee that led USGCRP (and to some extent MTPE/EOS) found itself engaged in turf battles with the OSTP Environmental office. "Who was in charge of what" became an issue that caused confusion in global change policy generally.[23]

Most importantly, Clinton made deficit reduction and economic growth his top priority and looked to NASA for budget savings. There was at first no guarantee that NASA's major program, Space Station *Freedom*, would survive the transition

22. Lambright, *NASA and the Environment*.

23. W. Henry Lambright, *The Challenge of Coordinating "Big Science"* (Washington, DC: IBM, 2003).

to the Clinton White House and the new Congress. Following Clinton's decision to reduce the space station in scale and then his decision to merge Space Station *Freedom* with Russia's *Mir-2* space station effort, the NASA flagship project was secured within the NASA budget. The president and Congress agreed to stabilize the budget of the newly rechristened International Space Station (ISS) in succeeding years. However, the overall NASA budget would hold steady or even decrease, thus putting strain on other programs.

Goldin applied his faster, better, cheaper formula to space science and MTPE, but his heart was clearly more with missions beyond Earth, especially Mars, than Mission To Planet Earth. He cut the MTPE/EOS budget further and brought Charles Kennell, an astrophysicist from UCLA, aboard to head MTPE. Shelby Tilford, architect of the EOS program under Fisk, departed, complaining that faster, better, cheaper was not better in EOS's case. The budget for EOS was now down to $7.25 billion for the period from 1993 to 2000. Kennell's job was to reorient EOS further and adapt MTPE generally to Goldin and administration priorities. Adaptation included Landsat's return. Landsat, a 1970s NASA initiative, had spun off in the 1980s to NOAA in what proved a fruitless effort to privatize the program. It now came back to NASA to become part of an effort to bring space remote sensing applications "down to Earth." The aim was to apply space remote sensing to agriculture, city planning, fisheries, and other practical concerns. The new emphasis won friends for the program in Congress and the states. The flagship MTPE program, EOS, continued in development but its ambition was lowered in accord with the budget.

Although MTPE won friends because of its new "down to Earth" approach, EOS continued to be a target of critics. Because of its association with global change and especially global warming, EOS continued to be controversial. When the Republicans gained control of Congress in 1995, they sought substantial cuts in EOS. Rep. Dana Rohrabacher (R-California), chair of the House Science Committee's Energy and Environmental Subcommittee, derided EOS as concerned with "scientific nonsense." Global warming, he charged, was at best "unproven and at worst . . . liberal claptrap." Goldin strongly defended MTPE/EOS and, in the end, the effort to make draconian cuts failed.[24] The budget projection did go down, however, to $6.8 billion, along with NASA's budget generally.[25] Defenders of EOS commented sardonically that it was "restructured," "rescoped," "rebaselined," and "reshaped." In the end, it stabilized around the development of three intermediate-sized, multi-sensor satellites, one oriented to land, another to water, and the third to the atmosphere.

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24. W. Henry Lambright, "The Rise and Fall of Interagency Coordination: The US Global Change Research Program," *Public Administration Review* (January, February 1997), pp. 41–42.

25. "Senators Rally Around NASA, Mission to Planet Earth," *The American Institute of Physics Bulletin of Science Policy News* (17 May 1996).

MTPE/EOS IN THE SECOND CLINTON ADMINISTRATION

There was relative stability for MTPE/EOS in Clinton's second term. To be sure, every year was a budget struggle. However, the precursor and applications missions showed results and the three EOS satellites made progress in development. Some of the partisan heat surrounding the program cooled, aided perhaps by NASA's changing the name of MTPE in 1998 to the more innocuous "Earth Sciences." The aim was to emphasize it as a policy-relevant, not policy-driven, science program—a subtle shift. Gore did not help NASA's effort to convey a neutral-science approach, however, when he proposed a new environmental satellite, called Triana, largely as an educational/inspirational tool. Detractors called it "Goresat" and Congress postponed its introduction, thereby taking some of the political heat off NASA.[26]

Meanwhile, positive results for the environment did flow from NASA precursor (i.e., pre-EOS) missions. The Agency's work in ozone was continuing to bear fruit. The UARS satellite helped NASA monitor ozone depletion and thus global compliance with the Montreal Protocol. Although it would take years for the ozone depletion problem to be fully alleviated, there was evidence that the depletion situation was beginning to improve.

Other important results in precursor missions lay with El Niño. Working with France, NASA developed a specialized satellite, called Topex-Poseidon, for measuring sea-surface temperatures. In March 1997, Topex-Poseidon detected a significant rise in sea level that spread across the Pacific toward the South American coast. In April, it found a rise in sea-level temperatures off the coast of Ecuador and Peru and monitored its spread north and south. This early discovery of a developing El Niño indicated that space technology, linked with other technologies of communication, could provide early warnings for natural disasters associated with the El Niño phenomenon.[27] Similarly, in 1998, NASA used the Tropical Rainfall Measuring Mission (TRMM) satellite to model more precisely the formation of hurricanes and other storms off the coast of Florida. Topex-Poseidon and TRMM again pointed up the practical value of environmental satellites. NASA's work in these "near-term" disasters was generally applauded. It still ran into controversy when it came to global warming, however. This was because it could not avoid what was happening in its political setting, where the controversy over the issue intensified.

26. Office of the Vice President, "Vice President Gore Challenges NASA to Build a New Satellite to Provide Live Images of Earth from Outer Space," The White House, Press Release (13 March 1998); "Scripps Institution, GSFC, Picked to Put Goresat at L-1 Point," *Aerospace Daily* (29 October 1998), article 117803. The satellite was eventually terminated. See Andrew Lawler, "NASA Terminates Gore's Eye on Earth," *Science* (6 January 2006), p. 26.

27. Madeline Nash, *El Nino* (New York: Warner Books, 2002), pp. 91, 114.

In late 1997, Vice President Gore defied Congressional sentiment when he went to Kyoto, Japan, and agreed to a protocol with other nations to cut back greenhouse gas emissions by a specific amount over a designated span of time. Clinton said he agreed with Gore but that he would not submit the Kyoto Protocol to the Senate for confirmation. He would instead emphasize voluntary measures to reduce emissions to Kyoto standards. The political consensus for binding emissions reduction and thus the regulation of the energy and automobile industries was not present, in Clinton's view. The political debate over Kyoto spilled over to make the setting for research on climate change more conflictual. [28]

In 1999, NASA launched the first of its climate-related EOS satellites, Terra. This satellite emphasized land masses but also had sensors relevant to other aspects of the physical environment. At $1.3 billion, Terra was intermediate in scale. Although far from the original concept, it was bigger than the faster, better, cheaper model Goldin had initially promoted. The remaining two satellites in the three-satellite series were scheduled to go up in the first term of Clinton's successor.

Environment at NASA Under George W. Bush

When George W. Bush became president in January 2001, the major policy question for the new administration involving NASA and the environment was: What would be NASA's role in environmental research after EOS? The answer has come slowly, tortuously, and is still emerging.

In March, Bush withdrew the United States from agreements under Kyoto. The negative reaction to that decision in the United States and Europe caused him to subsequently announce he would support research on climate change and take policy action if it proved necessary. The USGCRP was maintained under a new label, Climate Change Research Initiative, with the assistant secretary of commerce in charge of the interagency effort. For a year, NASA's Earth Science program was essentially on hold while the administration determined what it would do. Meanwhile, at the beginning of January 2002, Sean O'Keefe came aboard as new NASA Administrator. O'Keefe's priority was the ISS cost overrun, not Earth Sciences, but he provided support for EOS to complete what had begun under Goldin. The first EOS satellite was performing well, and the second, Aqua (costing $1 billion), was launched May 4. As its name implied, Aqua's mission was to study the global water cycle, including precipitation and evaporation.[29] O'Keefe also symbolized NASA's environmental concern by including in its mission statement the phrase "To understand and protect our home planet."

28. Lamont Hempel, "Climate Policy on the Installment Plan," in *Environmental Policy*, 6th ed., Norman Vig and Michael Kraft, ed. (Washington, DC: CQ Press, 2006), pp. 294–297.

29. Brian Berger, "NASA Aqua Mission to Study Global Water Cycle," *Space News* (29 April 2005), p. 18.

On 1 February 2003 the *Columbia* Space Shuttle disintegrated, killing all astronauts aboard. Once again, momentum for NASA's future, Earth Sciences included, was interrupted. That there would be some kind of future for Earth Sciences seemed clear. In the summer 2003, the State Department held an International Earth Observations Summit. The United States pledged to provide leadership in climate change research through an international "system of systems" in which satellite capabilities of many nations would be coordinated and linked. Following the conference, NASA announced it would develop on an accelerated pace a new, post-EOS, climate change-oriented satellite called Glory.[30]

On 14 January 2004, President Bush announced his Vision for Space Exploration (VSE) initiative, "To the Moon, Mars, and Beyond." In line with the new priority, O'Keefe reorganized the Agency, creating an Exploration Systems Division and merging NASA's separate Earth Science and Space Science programs into a single organization, the Science Mission Directorate. Proponents of Earth Science viewed the reorganization as a downgrading in priority. Advocates of reorganization argued that the moving of Earth and Space Science together promoted synergy and enhanced learning about planetary change in general from work on Earth, Mars, and other planets. They gave a comparative planetology perspective, one historically always present as part of NASA's environmental mission but usually as a background element. Now it was moved to the foreground to emphasize mutual learning from missions to and from Earth.

In July, NASA launched Aura, the third and final leg of EOS. Another billion-dollar satellite, Aura would make comprehensive measurements of the atmosphere and take over for the aging UARS in monitoring ozone trends.[31] The completion of EOS after so many years was a matter of relief for some Earth Science observers, but frustrating for others. Valuable though they would be, the EOS satellites were far short of the program creators' vision: large dual platforms providing comprehensive and simultaneous air, land, and sea interactive images over a 15-year time frame. There were many gaps in knowledge to be filled.

The more pressing problem continued to be: What next for Earth Sciences? Especially: What next in an era when Moon-Mars would increasingly shape all priorities for NASA? That is, the closer a program was to VSE, the more relevant it could be seen to be to NASA's future. The further away, the less relevant. There was a great deal of concern among scientists and administrators involved with NASA's environmental mission that, when push came to shove, they would suffer. Indeed, budget projections seemed to indicate that fact, as did a decision to cancel the Glory climate satellite. Moreover, there were rumors that the administration was considering moving much of NASA's Earth observation work to NOAA.

30. Brian Berger, "Reversing Course," *Space News* (25 July 2005), p. 10.

31. Tariq Malik, "Last EOS Satellite to Study Air Quality at Earth's Surface," *Space News* (14 June 2004), p. 8.

The future remained murky when O'Keefe departed and Michael Griffin came aboard as NASA's leader in April 2005. Griffin reversed a number of O'Keefe's decisions, including the Glory termination. Earth Science had friends in Congress, especially Sherwood Boehlert (R-NY), chair of the House Science Committee.[32] However, Griffin had to deal with the reality of increased shuttle repair costs and a relatively static overall NASA budget. If VSE were to move forward, money would have to come from lower-priority programs, including Earth Sciences. At the same time, the cross-pressured Griffin found himself dealing with a highly public dispute involving NASA's outspoken James Hansen. The NASA scientist complained to the media that administration appointees in NASA's public affairs office were censoring his statements about global warming. Griffin declared that NASA scientists could comment freely about science, and even its implications, but they should make clear that they spoke for themselves, not NASA, when they crossed the line into policy. A NASA public affairs official who had allegedly censored Hansen was fired when it was revealed he had lied about his educational credentials.[33]

In 2006 Griffin presented a budget that delayed various post-EOS missions but reinstated Glory.[34] EOS orbited and provided considerable information, but there was worry about whether there was enough money to analyze the information properly. There were also various older specialized satellites, including Landsat, which needed replacement in some way. NASA was a junior partner in a NOAA-Department of Defense operationally-oriented system called the National Polar Orbiting Operational Environmental Satellite System (NPOESS). For a while, the Bush administration seemed intent on linking NASA's post-EOS climate science future to NPOESS, but when NPOESS ran into budget problems of its own, connecting NASA's climate role to NPOESS lost a great deal of its rationale.[35]

What NASA needed was an overarching strategy for its future in Earth Science, one like the one it developed in the 1980s prior to the birth of MTPE and EOS. To help provide advice, the National Research Council undertook an Earth Science decadal survey on priorities in the next 10 years. To be completed by November 2006, the survey was intended to help Griffin determine what made sense for the Earth Sciences program. Griffin, in turn, would require major decisions from the White House and Congress to set NASA on a course fruitful both for science and climate policy.

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32. Brian Berger, "NASA's Exploration Focus Blamed for Earth Science Cuts," *Space News* (2 May 2005), p. 4.

33. Rick Weiss, "NASA Sets New Rules on Media," *The Washington Post*, 31 March 2006, p. A10; Warren Leary, "New NASA Policy Backs Free Discussion by Scientists," *The New York Times*, 31 March 2006, *http://www.nytimes.com*.

34. Berger, "Reversing Course."

35. Jeffrey Mervis, "Climate Sensors Dropped from US Weather Satellite Package," *Science* (16 June 2006), p. 1580.

Without question, the Earth Science program was at a crossroad. NASA's environmental role was not explicitly mentioned in the overarching NASA mission statement of 2006. The phrase O'Keefe had used in his mission statement—"To understand and protect our home planet"—was gone. The new Griffin mission statement read "To pioneer the future in space exploration, scientific discovery, and aeronautics research."[36] Whether the omission was symbolic or substantive remained to be seen. The basic problem NASA Administrator Griffin has faced is that he has too many programs on NASA's plate and not enough money for all.

CONCLUSION

How did NASA evolve an environmental mission? The answer is that it did so gradually and somewhat tortuously, with ups and downs along the way. What did it do with that mission? It did a great deal that was positive in a host of ways, but with special significance in regard to ozone depletion and the Montreal Protocol. What has this meant for society? It has meant benefits in knowledge with spillover into policy. What has the environmental mission meant for NASA? It has meant enmeshment in a political context that has helped it survive and grow at some points in history and made it extremely controversial at other times.

Taking the long view of history, NASA has had an enormous impact on environmental policy since its founding in 1958. The weather satellite and its successors, developed by NASA and transferred to operational use, have saved lives and money through early warnings of hurricanes and improved weather forecasting. The first pictures of Earth from the Apollo program crystallized the vulnerability and beauty of Earth and were used by environmentalists to mobilize support for the first Earth Day in 1970. As the environmental movement gathered momentum, NASA in the 1970s aligned itself with the new imperative and extended its weather satellite effort to land- and sea-oriented images. This activity took place as NASA's planetary program stimulated a comparative planetology consciousness in which Earth seemed increasingly unique as a home to life. The Gaia Hypothesis, which emerged from comparative planetology, stressed thinking about Earth as a living system of interacting and interdependent parts.

In 1972, with Landsat, NASA initiated a long series of Earth monitoring satellites. In doing so, it became more and more, as NASA administrator Fletcher said, "an environmental agency." Becoming "an environmental agency," through the science it provided, immersed NASA in the controversies and political emotions surrounding the environmental question. Sometimes the political winds were favorable to NASA; at other times they were not so. In the 1980s NASA, armed with

36. Andrew Revkin, "NASA's Goals Delete Mention of Home Planet," *The New York Times,* 22 July 2006.

legislative authority gained in the 1970s, played a lead role within the government in responding to the ozone depletion threat. It was the ozone crisis that provided a proactive model for NASA as an environmental agency, one that could conduct and transfer policy-relevant science. Advocates of a larger global environmental mission sought to build on the ozone success to position NASA for an expanded role. After *Challenger*, in 1987 Sally Ride listed Mission To Planet Earth as first among new initiatives that could galvanize a shaken agency and make it more relevant to American society and the world's needs.

Such a mission seemed ripe indeed in the wake of the Montreal Protocol as the new concern about climate change rose on the nation's agenda, propelled in part as NASA's James Hansen. President George H. W. Bush and Congress in 1990 provided authority and initial funding for MTPE and its centerpiece, EOS. However, in the 1990s, MTPE ran into a budgetary crunch and competition with other NASA programs—human spaceflight and space science—and was never funded as its founders expected. EOS was downsized and split up, subject not only to budget constraints but also pressures to conform to Goldin's faster, better, cheaper doctrine. What finally was launched as EOS in 1999, 2002, and 2004 was a much circumscribed version of what its architects had planned in the late 1980s. The system could not realize the promise of a 15-year comprehensive data set from the simultaneous monitoring of land, sea, and atmosphere interaction. A new Earth System Science got started but did not get as far as expected. The "predictive capability" remained to be developed for global change.

With ozone depletion, NASA had legitimacy to lead and a crisis context in which there was science push and policy pull. With climate change, however, NASA had no special mandate to lead and the science push has come gradually in a societal context where the perception of crisis is lacking. Rather than policy pull, there has been policy discord and even "push back."

A strategy for the post-EOS era has yet to be fully charted and adopted, much less implemented. Agreement on next steps has to be forged. It is easy today for advocates of global environmental satellites to see a glass half empty. However, a more positive, glass half-full view surely would say that it is remarkable how much a space agency has done in directing attention to Earth. NASA is the space research and development arm of the federal government when it comes to global environment. In addition to EOS, there have been numerous specialized satellites that have monitored ice melting, El Niño, storms, and others ills. Ozone provides a genuine success story in science and public policy. There was science-push and policy-pull. Climate change is not a success story yet. If one were giving grades, NASA would get an "A" for ozone depletion and "Incomplete" for global climate change. Having said that, the problem of climate change is more complex than ozone for many reasons, and there has been consensus-building progress, at least on the science side. There is a limit to what NASA (and science generally) can do in eliciting policy response, however.

The dilemma NASA now faces in designing a post-EOS future is shared with other agencies associated with the global change initiative of the early 1990s. This interagency initiative never was fully implemented, coordinated, or led. There is a need to re-energize the vision many of the early advocates of EOS and USGCRP had—a strong Earth system science and a capacity to predict global change (especially climate change)—that can be put to policy use. Achieving such a vision requires a planetary perspective and that is NASA's distinctive environmental competence. It is based on NASA's mission to the home planet *and* the comparative approach derived from its work beyond Earth. That perspective needs renewal and advocacy for a twenty-first century setting. That setting almost surely will be influenced, perhaps dramatically, by events involving climate change. Remaking NASA's environmental mission, with resources to match, and connecting that role to other agencies and nations is a challenge. It is less a problem in science and technology, however, and much more a challenge of political will.