EARTH SCIENCE

Terra Launch Spotlights NASA Observing System

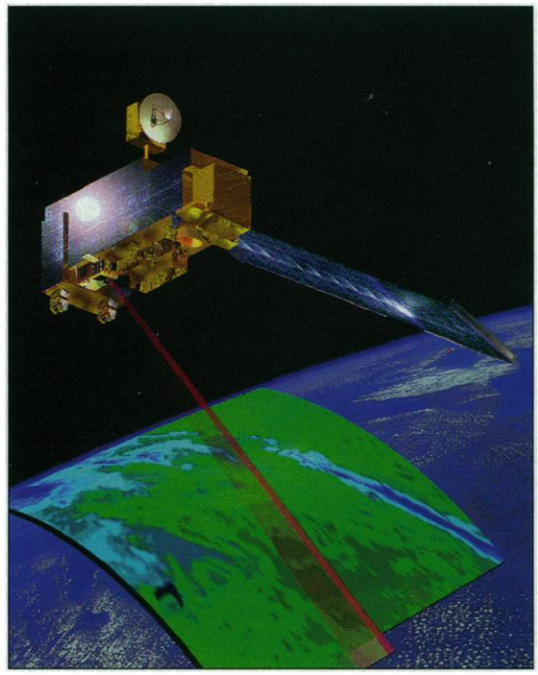
Next week's launch of the first of three satellites marks the debut of a smaller, cheaper version of a controversial effort to monitor Earth from space

It has been restructured, rescoped, reviewed, and reviled. But next week the first of three major satellites to be launched under NASA's controversial Earth Observing System (EOS) program is scheduled to head into orbit. The 10-year, $7.25 billion program will gather data on how the planet's processes create climate and whether humans are seriously altering those processes. Along the way, NASA officials also hope to quiet concerns from scientists that the agency has gone too far in favoring hardware over data analysis and has reneged on its original long-term monitoring plan aimed at unlocking climate's deepest secrets.

The scheduled 16 December launch from Vandenberg Air Force Base in Lompoc, California, will be both a triumph and a relief for NASA and the hundreds of researchers who have labored on the project. The 5000-kilogram, $1.3 billion Terra spacecraft will be followed in the next 3 years by Aqua and Chem; each carries an array of instruments that probe, at various wavelengths, everything from cloud development to sea temperatures to vegetation growth. Data from the trio will be supplemented by more than a dozen smaller U.S. missions and a variety of international missions under way or in preparation. "EOS represents a sea change" in the way earth scientists are able to monitor the planet, says Rafael Bras, a Massachusetts Institute of Technology hydrologist and chair of the NASA advisory panel that oversees the agency's earth sciences program. "For the first time, we are setting out to understand the [whole] Earth system."

That goal is about the only thing not changed since the program was conceived. The current EOS is a slimmed-down version of the massive platforms, intended to gather data for at least 15 years, that were envisioned in the 1980s (*Science*, 1 September 1995, p. 1208). The program has also suffered delays—Terra is 2 years behind schedule—and cost overruns, sniping by skeptical legislators, and complaints from scientists about its complex data system and insufficient research funds to complement the sophisticated hardware. With Terra on the launching pad, government officials are now searching for ways to keep the data flowing once the three spacecraft complete their mission.

EOS began in the era of large, costly missions, before NASA Administrator Dan Goldin's "faster, cheaper, better" diktat. "It was done Soviet style—big and clunky," recalls Jerry Mahlman, a Princeton atmospheric modeler and former chair of the NASA advisory panel for earth sciences.



Pollution police. This Canadian instrument aboard Terra hopes to provide the first long-term, global measurements of carbon monoxide and methane gas levels in the lower atmosphere.

CREDIT: CANADIAN SPACE AGENCY

The initial concept was to build a few mammoth platforms carrying 30 instruments. Each would beam data to a complex centralized data system at NASA centers, which in turn would distribute information to everyone from researchers to high schoolers. The satellites would be replaced as they wore out, providing for continuous coverage. "This was not necessarily sold on science but on dreams, what's cool, and what's internationally spectacular," says Mahlman.

Those grandiose plans were scaled back, however, after predicted costs for EOS rose as high as $33 billion, provoking the concern of top NASA management and an outcry from Congress. A half-dozen redesigns later, EOS has evolved into a mix of small and large spacecraft, with a more decentralized data system and no immediate plans to replace the three major satellites. In addition, Congress in 1994 capped EOS spending at $7.25 billion.

Ghassem Asrar, the NASA earth sciences chief who has headed the program since 1998, says that the present configuration provides "sufficient flexibility to focus on specific scientific questions while providing a continuous flow of data." But not everyone agrees. "The frustration is that EOS started as a long-term observing system, but now we've screamed off in the other direction of individual research missions," says Bruce Wielicki, a principal investigator for a clouds and Earth radiant energy experiment on both Terra and Aqua and a radiation scientist at NASA Langley Research Center in Hampton, Virginia. Wielicki and other researchers want long-term and continuous coverage, while others argue for fast and intensive missions. "There are two camps," acknowledges Asrar, who says NASA has done its best to supplement Terra, Aqua, and Chem with separate missions to examine the effect of Earth's gravity on ocean circulation, the thickness of the world's ice sheets, ozone levels, and the amount of the sun's energy that falls on the planet's surface.

There's also no commitment to extend these activities beyond 2006. NASA lacks a long-term, integrated science plan, notes a March 1999 National Research Council study on the fate of EOS beyond 2002. "EOS doesn't speak to continuity in ... looking at how climate fluctuates," says Mahlman. "It's up for a few years and then you bag it. And if you don't have continuous measurements, then what exactly are you doing?"

NASA officials say that the three spacecraft could operate for a decade or more, twice their estimated lifetimes. One possible solution lies with a new generation of spacecraft, slated for launch in 2008 or so, that combines the fleets of the National Oceanic and Atmospheric Administration and the Defense Department. Scientists see them as a natural platform for their research instruments, alongside short-term weather forecasting equipment. "In the long run, the problem is that NASA is not the right agency to take on operational missions," says Mark Abbott, an oceanographer at Oregon State University in Corvallis who is chairing a National Research Council committee studying a planned merging of government

weather satellites. The committee, in a report due out early next year, is expected to recommend the launch of an interim satellite in 2005 or 2006 to plug the data gap; the topic is already under review at the White House.

Although most scientists would applaud such a mission, they point out that orbital mechanics prevent a single spacecraft from meeting all their needs. Researchers interested in land processes, for example, prefer a satellite that follows the path of the early sun, gathering data in the morning, before clouds set in. But those interested in clouds and humidity want data from the afternoon. One way to tackle the problem, says Asrar, is for NASA and U.S. scientists to work with overseas colleagues to develop "an international strategy," which might include a European platform.

Earth manager. Ghassem Asrar oversees NASA's Earth Observing System program.

In the meantime, many researchers remain unhappy about the EOS data system, which will control the onboard instruments as well as process, distribute, and archive data. The question of access divides investigators, who want a system tailored to their needs, and government officials, who also want it available to the public. The revamped system is far less cumbersome than the original concept—it was "monstrously overgrown," says Mahlman—and gives investigators much greater control over distributing and even processing their data. But the need to keep it open for public use rankles many. "You need different systems, one for gunslinger users and one that is friendly to high schoolers," says Mahlman, who says he resigned as advisory chair 3 years ago out of frustration with NASA's pace in revamping EOS. Last year Goldin, under pressure from Senator Barbara Mikulski (D–MD), vetoed further attempts to simplify the system and restrict access.

Scientists also chafe at the fact that well over two-thirds of EOS funding has been for hardware and feel that research has been given short shrift. "Is that cost effective and balanced?" asks Mahlman. Richard Somerville, a climatologist at the Scripps Institution of Oceanography in La Jolla, California, and a member of the NASA advisory panel, agrees. "It's a pity NASA is pinched when it comes to supporting research. The scientific payoff from the data could be greater," he adds, if more funds were devoted to research. But Asrar defends the allocation. More than 20% of his office's $1.4 billion has been set aside for data analysis, he says, a figure that he hopes will rise to 30% within a few years. When funding from other agencies such as the National Science Foundation is taken into account, he notes, "I think this issue goes away."

From the beginning, however, some scientists have wondered whether the huge investment in EOS will yield equally huge results. Bras is upbeat, but some scientists say the program is hobbled by the fact that it has served more as a wish list for researchers than an exercise to answer specific scientific questions. As a result, says Richard Goody, a Harvard planetary physicist who was involved in the early planning, "EOS will be helpful, and we will learn something from it, but I don't think it moves us to an objective of making predictions from climate models more believable."

Those debates are likely to remain contentious for years. But next week they will be set aside as researchers hold their breath and hope for a successful launch. "The stakes are very high," says Asrar. "The hopes and dreams of a large segment of the community are tied to this." **–ANDREW LAWLER**

EUROPEAN UNION

Research Chief Wants to Make Science Matter

Philippe Busquin wants science at the heart of EU decision-making, but Brussels bureaucracy doesn't give him much room to maneuver

BRUSSELS—Philippe Busquin, the European Union's new research chief, has a tough job ahead of him. For 2 decades, the EU has been pouring billions of euros into cross-border research projects, yet the community of European scientists remains fragmented and insular compared to their colleagues across the Atlantic. Research funding, on average, lags behind the United States and Japan; many postdocs would rather look for positions in North America than in another European nation; and because national governments jealously guard their right to make most of the big research funding decisions, the EU's research directorate has had a hard time bringing much cohesion to the European scene.

Busquin would like to change all that. He wants to encourage more mobility and cooperation among Europe's top researchers, overhaul some of the EU's own research labs and big-ticket science programs, and bring the directorate's scientific expertise to the heart of EU decision-making. "We must give a new dynamic" to European research, Busquin told *Science* in an interview last month. "There is a wide range of issues in which science should have a major input" in Europe, he said, but boosting that input will require more coordination among the science policies of the member states and other European organizations.

Can Busquin pull it off? In theory, he is well placed to put his stamp on European science. As one of 19 commissioners, he holds a position in the EU executive roughly equivalent to that of a Cabinet member in a national government. And as head of the EU's Framework 5 program, he commands a budget of nearly $4 billion a year—more than most research managers, such as the heads of the U.K. research councils or France's CNRS, have to play with. But even that amount represents less than 4% of Europe's total research spending, and it comes with some heavy political baggage. In general, the research ministries of France, the United Kingdom, Germany, and other major EU nations distrust the Brussels bureaucracy and keep a tight grip on decisions about "big-science" issues. Europe's major research facilities—including the CERN

Philippe Busquin. European research needs "a new dynamic."

CREDITS: (TOP TO BOTTOM) NASA; KARIM IBOURKI/PHOTO NEWS