
Planned NASA satellites will measure the vertical motions that lead to towering storm clouds. SANTIAGO BORJA

NASA’s new fleet of satellites will offer insights into the wild cards of climate change

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NASA is about to announce its next generation of Earth-observing satellites. As soon as this month, it will lay out preliminary plans for a multibillion-dollar set of missions that will launch later this decade. This “Earth system observatory,” as NASA calls it, will offer insights into two long-standing wild cards of climate change—clouds and aerosols—while providing new details about the temperatures and chemistry of the planet’s changing surface. The satellite fleets also mark a revival for NASA’s earth science, which has languished over the past decade compared with exploration of Mars and other planets.

Although officials have been planning the missions for several years, the Biden administration is accelerating them as part of its focus on addressing climate change. “Earth system science is poised to make an enormous difference in our ability to mitigate, adapt to, and plan for changes we’re seeing,” says Karen St. Germain, director of NASA’s earth science division. “The pace we’re going to have to do that is much higher in the decade in front of us than the decade behind us.”

Agency spokespeople declined to provide details about the missions because they have not yet been formally approved. But at a **workshop last month**, Charles Webb, an associate director for flight programs at NASA, said four missions would go ahead, launching as soon as 2028—an acceleration of plans under the Trump administration, when only two missions were scheduled to begin development. “It became pretty clear the greatest science return is having all of these in operation close to each other,” Webb said. The missions lack official names, but go by the shorthand of ACCP (Aerosol, Cloud, Convection, and Precipitation), which covers two missions; Surface Biology and Geology (SBG), and Mass Change , which would measure tiny variations in gravity indicating changes in ice and water.

The administration’s proposed 15% bump for NASA’s earth science budget for next year, to $2.3 billion, would help fund the accelerated program. The increase would also be welcome news for NASA’s earth science researchers after 2 decades operating under administrations leery of climate. Jeremy Werdell of NASA’s Goddard Space Flight Center recalls multiple attempts by the Trump administration to kill Pace, a $900 million ocean-monitoring satellite for which he is principal investigator. “You’d see the chart with all the upcoming missions, and you’d see yours isn’t there.” (The mission survived and is due to launch in 2023.) However, even President Joe Biden’s proposed investment would leave NASA’s inflation-adjusted spending on earth science below the levels 20 years ago, says Waleed Abdalati, director of the Cooperative Institute for Research in Environmental Sciences at the University of Colorado, Boulder, and former NASA chief scientist. “We’re well behind where we were.”

The **ACCP satellites**, with a total cost of up to $1.6 billion, would replace CloudSat and CALIPSO , probes launched in 2006 that **have provided clarity** on how clouds and aerosols can either slow global warming, by reflecting sunlight, or speed it by trapping heat. CloudSat, able to spot previously invisible light rain and snowfall, provided the first global picture of total precipitation. The pair also showed that certain aerosols, when mixed with clouds, can suppress rainfall and extend clouds’ lifetimes and their ability to block light. “We learned yes, this is an effect we can observe,” says Tristan L’Ecuyer, a climate scientist at the University of Wisconsin, Madison—and one that human-caused pollution, like soot, may amplify.

But the satellite duo is aging: CloudSat has lost two of the four reaction wheels it uses to stabilize its orbit, and CALIPSO is out of fuel and onto its backup laser. The three or more satellites of the ACCP missions will pick up where these two left off, with more precise measurements that can reach closer to the planet’s surface to quantify the response of low clouds to warming. They will be armed with two primary instruments: an advanced laser capable of identifying individual aerosol types, such as smoke from a volcanic eruption or dust blown off the Sahara; and several bands of radar, including a Doppler instrument that can detect the vertical convective motions that drive major storms. “We’re still trying to understand why hurricanes intensify,” L’Ecuyer says.

SBG, the **chemistry and temperature mission**, which would cost up to $650 million, will include a satellite with a high-resolution hyperspectral imaging spectrometer that can subdivide reflected light into more than 400 wavelength channels across the visible and into the infrared. It serves as a **molecular mapping system**, sensitive to the spectral signatures of specific gases in the air column below or compounds at the surface.

By measuring the intensity of green chlorophyll or detecting the signatures of excess salts or fungus, for example, researchers can evaluate the health of crops and forests. They will be able to prospect for minerals in remote regions, map and identify different coral and algae species, and track plumes of greenhouse gases. “Spectroscopy truly is the future of planetary imaging,” says Greg Asner, an ecologist at Arizona State University, Tempe, who has tested airborne prototypes of the spectrometer. (A smaller scale version will be **launched and mounted** on the space station next year.)

Another satellite in SBG would host a thermal radiometer, capable of capturing the heat coming off Earth’s surface. Such an instrument is already mounted on the space station for the Ecostress mission, where it watches for the high leaf temperatures that result when plants run short of water. Ecostress data also reveal the heat of wildfires and volcanoes, track warming ocean currents, and pinpoint urban heat islands. SBG would cover the whole globe, not just the midlatitudes as Ecostress does, while capturing three times as much land with each path. “It’s a really rich future,” says Simon Hook, Ecostress’s principal investigator at NASA’s Jet Propulsion Laboratory.

Less is certain about Mass Change, beyond that the mission—likely a partnership with European space agencies—will continue the measurements made by the Gravity Recovery and Climate Experiment Follow-On (GRACE-FO), which calculates tiny shifts in Earth’s gravity from the fluctuating distance between two satellites flying in tandem. GRACE-FO has allowed scientists to measure ice loss in Greenland and Antarctica and monitor water loss in soil and underground aquifers due to drought. Mass Change will include a tandem of satellites similar to GRACE-FO, which flies in an orbit around the poles. Scientists also hope the mission will fly a second set in a different orbit to reduce distortions in the gravity signal it collects.

With NASA planning to turn powerful new eyes on Earth, NASA’s earth scientists see a brighter future for their work, if not for the beleaguered planet. “We’re in a time of challenge, there’s no doubt about that,” St. Germain says. “But it’s also a time of unprecedented opportunity.”

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