Save the Earth… and space

Historical under-regulation of the Earth's atmosphere and the orbital space around it have brought the astronomy and space communities to a critical point at which action is needed to move towards a sustainable future.

In almost exactly five years from now, Voyager 1 will be a light-day away from Earth, shooting off in the general direction of the Gliese 445 star system. At that point its primary purpose will have been served, its power source will have failed and essentially Voyager 1 will become an inert relic of human space exploration heading off into the darkness. Voyager 2 and eventually New Horizons will experience a similar fate, followed by the already-derelict Pioneers 10 and 11. Lagging in the wakes of these scientific trailblazers are the means of getting them where they are now: their final-stage rockets, and in the case of New Horizons, two small yo-yo de-spin weights. Other spent spacecraft litter the surfaces of our Solar System, from distant Huygens sitting on the surface of Titan or Philae resting in a crevice on comet 67P/Churyumov–Gerasimenko, to the remnants of more than 80 missions — including flags, tools, golf balls, a statuette and a Bible — on the Moon. In total, hundreds of pieces of human detritus are scattered throughout our Solar System environment. Most of these items are impossible to 'clean up': either they cannot be retrieved with today's technology or it is economically unfeasible to do so.

In Earth's orbit there are more than 22,000 objects of appreciable size, according to the General Catalog of Artificial Space Objects. Only about a fifth of these objects are active, performing important duties in communication, global positioning, Earth monitoring, national defence, astronomy, and so on. The remaining 17,500 are litter: dead satellites, exhausted rocket stages, other general space debris. While current levels are already somewhat worrying, thousands of new objects are now being launched into orbit every year — notably to bolster communications constellations such as Starlink and OneWeb — while only a much smaller number leave orbit, burning up on re-entry or experiencing hard stops on the Earth's surface. The population of active satellites has been estimated to grow to 100,000 by the end of the decade, and with a typical lifetime of five years, the growth of associated 'junk' in Earth orbit will rise dramatically. Modelling suggests that disabling collisions between debris and active satellites would occur hundreds of times per year (compared to effectively zero currently).

Such a proliferation of orbital objects has stimulated a growing concern, with 'space sustainability' becoming a subject of debate amongst the G7 and in the World Economic Forum. Technology now exists to remove this space junk from orbit (such as ELSA-d and ClearSpace-1), but since economic feasibility is still not attractive, it is more conducive to think of a prevention of this littering rather than a cure. While environmental impacts on the surface and in the atmosphere of our planet are largely controlled and regulated on a national level, the environmental impact on the space around our planet is comparatively less so, and is an inherently global issue. A treaty and a convention from the early days of the space race — before the realities of satellite constellations and anti-satellite weapons were comprehended — do much of the heavy lifting, and much expectation is placed on active satellite operators to park or de-orbit satellites at the end of their lives. In this issue of *Nature Astronomy*, a number of experts call for there to be tighter regulations of near-Earth orbital space and for this space to be considered an environment with similar protections as other environments on Earth. The Perspective article contains information submitted to the US Court of Appeal in opposition to a licence granted by the Federal Communications Commission for the deployment of SpaceX Starlink satellites. The experts identify three aspects of this near-Earth environment that should be more closely controlled: the radio regime, to reduce radio interference in order to ensure fair access to radio communications and also to preserve radio astronomy; the optical sky, to reduce light pollution in order to ensure equitable visual access to the sky, important in cultural traditions and optical/near-infrared astronomy; and orbital space, to allow the safe sharing of the available capacity for satellite traffic.

Besides the environmental concern of the build-up of space junk in near-Earth orbital space, another environmental consideration weighing on the minds of astronomers is the impact of their research activities upon climate change. In recent years, astronomers have been getting ahead of the curve in quantifying their carbon footprints, in order to more effectively target strategies for the reduction of greenhouse gas emissions and limit the degree of global warming. A number of articles in *Nature Astronomy* and elsewhere have identified supercomputing and academic flying as major contributors to the carbon footprint of astronomers, however a paper in this issue from Jürgen Knödlseder and colleagues identifies astronomical research infrastructures (such as ground-based observatories and space missions) as the biggest source of carbon dioxide. In the relentless quest for larger telescope mirrors or dishes on the ground and in space, both the mass and cost — the two quantities used as bases for the CO_2 estimates — of new and future facilities are skyrocketing. While it is encouraging to see the builders of future facilities such as the Extremely Large Telescope and the Square Kilometre Array taking sustainability seriously, Knödlseder and colleagues suggest that carbon budgets for new infrastructures should be regulated at a wider level by funders and space agencies, who would ideally have a bigger and longer-term picture of a sustainable future. It may take the slowing down of developing infrastructures in astronomy in order to meet future constraints.

In either case, whether it be the environment directly around us or far above our heads, there is a pressing need for far-sighted regulation that would preserve the precious resources that we currently have, and create a vision for a sustainable future for astronomy and beyond. ❐

Published online: 22 April 2022
https://doi.org/10.1038/s41550-022-01676-1