Planetary rite of spring

Research on the Solar System's planets has moved beyond fly-by science. Long-term observations of planetary bodies can yield insights as the days, seasons and years pass.

Spring is here in the Northern Hemisphere on planet Earth. Birds chirp, flowers bloom, and trees sprout fresh leaves. Meanwhile on Mars, which takes about twice as long to circle the Sun as Earth, northern spring is still in the offing. A surface that responds dynamically to the changing seasons has been chronicled by a succession of spacecraft that have been orbiting Mars continuously for almost two decades. Over in the Saturnian system, where a year lasts about 29 Earth years, the season is currently shifting slowly from spring towards the first summer in the northern hemisphere that has been observed through the cameras of the Cassini spacecraft. We commonly think of planets as static cratered landscapes devoid of change. But as three papers in this issue demonstrate, planets hosting atmospheres — and thus climate systems — are dynamic worlds both on the ground and aloft. There is great scientific value in the continuous monitoring of our planetary neighbours for understanding how these planets change with time.

Over the past decade, Cassini has been offering glimpses of Saturn's moon Titan over part of a Saturnian year. Radar imagery has revealed vast linear dune fields at the lower latitudes. The processes that form these dunes are probably not so different from analogous linear dunes seen on Earth that are built of wind-blown sand — although unlike on Earth, the sand grains are probably made of hydrocarbon compounds. Like on Earth, dunes on Titan are on the move.

Perplexingly, Titan's linear dunes appear to migrate from west to east, while the prevailing winds at low latitudes blow from east to west. The answer to this paradox may lie in Titan's seasons. Numerical simulations show that tropical methane storms, which have been observed by Cassini during the equinox, can produce gusts of wind that blow from west to east and may dominate sand transport (page 362). That the tropical storms only occur during equinox implies that the dunes evolve over long timescales. Another analysis — of the reorientation of small dunes — has attributed the apparent slow evolution of Titan's dunes to changes in

NASA/JPL-CALTECH/SSI

wind direction and sediment availability driven by long-term climate cycles[1]. Clearly, understanding Titan's dune dynamics requires consideration of a whole range of timescales, from the moment required for the saltation of a grain of sand in a single gust of wind to long-term orbital changes (page 334).

In contrast to Titan's slowly-shifting aeolian landscapes, on equatorial Mars, some dunes appear to be fully explained by current wind conditions[2]; here, the dunes are evolving on timescales much shorter than orbital cycles. But observations of polar dunes on Mars over the past several years have revealed interannual variability in dune morphology, with most changes taking place between the late summer and winter seasons[3].

Fifteen years ago, the identification of gullies on Mars that change with time[4] revealed an active Martian surface on seasonal timescales, although it remains unclear whether the gullies are the products of dry or wet flows. More recently, enigmatic streaks have been observed to appear and lengthen on sloping terrains during warmer seasons in the mid-latitudes and equatorial regions. The streaks are consistent with the seasonal flow of briny water[5], but how liquid brines could be stable at such low latitudes has remained an open question. An analysis of environmental data from the Curiosity rover at equatorial Gale crater, presented on page 357, shows that the answer again is in the dynamic nature of Mars: at night temperature and humidity conditions are sufficient to form brines in the subsurface.

Saturn too is dynamic from year to year. Since telescopes have been trained on Saturn, huge planet-encircling storms have erupted on the gas giant about every 30 Earth years. The regular occurrence of these so-called Great White Spots (pictured) is attributable not to the seasons, but to the thermodynamics of Saturn's atmosphere, concludes a Letter on page 398: water vapour in Saturn's atmosphere suppresses moist convection for decades until the progressive cooling of the troposphere triggers a giant storm. Then the cycle repeats.

As the Cassini mission winds down, we've already seen our first glimpses of spring in the northern hemisphere of Titan where active surface processes have been spotted in a sea[6]. Unfortunately, monitoring of the Saturnian system will be limited to half a Saturn year. As we have learned from satellite observations of Earth's weather and shrinking ice caps, for example, there is much to learn about a planetary system at seasonal, annual and longer timescales. The benefits of long-term continuous observation of a planet have been demonstrated on Mars, as documented this month in a collection of papers in the journal *Icarus*[7] — the product of two decades of data tracking changes to the atmosphere and surface of the Red Planet.

Sadly, it seems unlikely that it will be possible to maintain a continuous spacecraft presence at Titan for an entire Saturnian year. So at least for the current annual cycle, our picture of the seasonal progression of Saturn and its moons will have to remain incomplete. ❐

References

1. Ewing, R. C. *et al. Nature Geosci.* **8,** 15–19 (2015).
2. Chojnacki, M. *et al. Icarus* **251,** 275–290 (2015).
3. Hansen, C. J. *et al. Icarus* **251,** 264–274 (2015).
4. Malin, M. C. & Edgett, K. S. *Science* **288,** 2330–2335 (2000).
5. McEwen, A. S. *et al. Nature Geosci.* **7,** 53–58 (2014).
6. Hofgartner, J. D. *et al. Nature Geosci.* **7,** 493–496 (2014).
7. Bridges, N. T. & Tamppari, L. K. *Icarus* **251,** 1–4 (2015).