Prime Meridian

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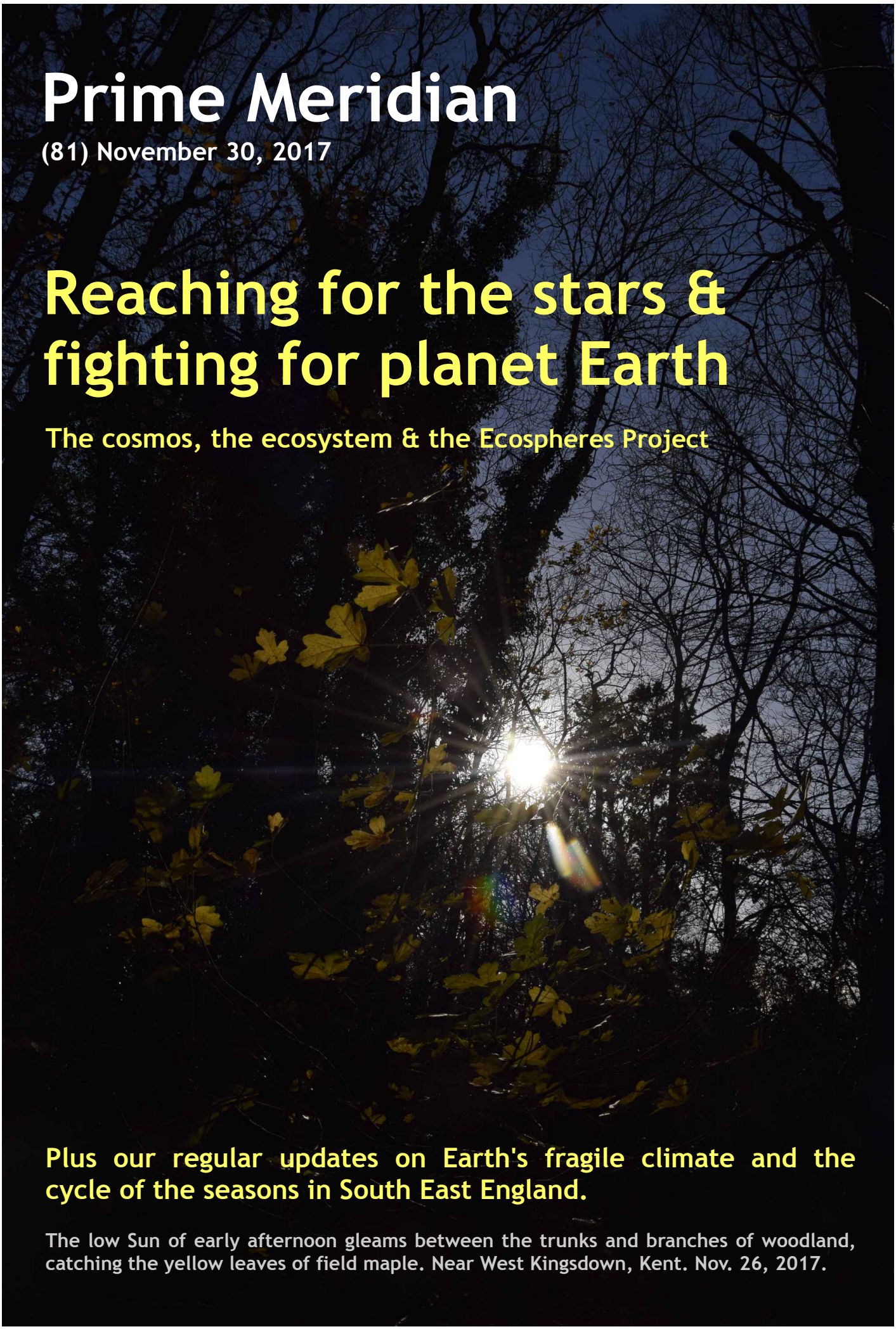
Reaching for the stars & fighting for planet Earth

The cosmos, the ecosystem & the Ecospheres Project



Plus our regular updates on Earth's fragile climate and the cycle of the seasons in South East England.

The low Sun of early afternoon gleams between the trunks and branches of woodland, catching the yellow leaves of field maple. Near West Kingsdown, Kent. Nov. 26, 2017.

The cosmos and the ecosystem.

The Ecospheres Project has a two-fold mission statement. On the one hand, we are looking to the stars as we explore the challenges and opportunities for life beyond the Earth. On the other, we are campaigning, alongside many other organisations, to safeguard life here on Earth. Human communities threatened by global change are among our major concerns.

At first sight, these two endeavours may appear to be headed in opposite directions. Some might even misunderstand them to be contradictory.

In reality, they are intertwined inextricably. Our enthusiasm for the possibility of other habitable planets emerges from our passion for the world on which we live. Climate and other Earth sciences, alongside the life sciences, are the foundations for discussions about the possibility of other habitable planets.

Indeed, as scientific knowledge exploded during the last Century, it became more necessary than ever before for researchers to specialise. However, we do not see the world as a collection of isolated specialisms (these have been created artificially for human convenience), but as an awesomely complex set of inter-relationships for which there are no boundaries.

Our track record as a collaboration has been in horizon-scanning exercises, where we have highlighted and pioneered areas that have subsequently developed into major topics of research in their own right (a two page summary is available on our website; see last page). We are keen, at the same time, to bring together into synergy complementary insights that have developed in sections of the scientific community between which there has been a limited exchange of ideas.

In terms of research, much is to be gained from crossing boundaries. Likewise, in our experience of promoting the public understanding of science, people love to be shown unsuspected connections between what might have previously appeared to be unrelated aspects of the world. This is a great technique for bringing science alive for the layperson.

A concept that draws the physical world into a unity is that of the *ecosystem*. Our approach to life beyond the Earth emphasises the importance of understanding organisms as integral members of such systems. The very definition of the word "ecosystem" is an open invitation to engage with the big picture.

It was the German researcher Ernst Haeckel (1834-1919, seen right in 1860) who appears to have first devised the term "*ecology*" (oecology, from the Greek οικος meaning "*home*") for the study of organisms in relation to each other and their environment. The concept of the *ecosystem* was introduced explicitly by the British scientist Sir Arthur George Tansley (1971-1955; seen lower right in 1893), whose associate Arthur Roy Clapham (1904-1990) coined the term at his behest.

Tansley (1935) explained that an ecosystem comprises (p. 228): "all the physical and chemical components" of the associated environment and (p. 299) "There is a constant interchange within each system, not only between organisms but between the organic and the inorganic." The ecosystem was (p. 306): "The fundamental concept appropriate to the biome considered together with all the effective inorganic factors of its environment". Tansley, A. G. (1935). *Ecology* 16: 284-307.

For ecologists, "ecosphere" means a planetary-scale ecosystem.

For us, the key part of the definition of an ecosystem is that it comprises *all* relevant physical factors. This embraces the whole universe.

Looking at life's environment, ecologists, for good, practical reasons must concentrate mostly on climate, bedrock, soil development and landscape. Recent geological history will be important too. Over large parts of the northern latitudes, the landscape owes its characteristics to deep scouring by glaciers, with sheets and mounds of gravels, clays and erratics left behind after the climate, swinging between ice ages and the temperate intervals, turned warmer.

These, however, are by no means an all-embracing description of the physical factors affecting an ecosystem, which are nested in a hierarchy from the cosmic down to the local. Fundamentals include the dimensionality of space and time (three dimensions of space, one of time and, in some theories numerous hidden dimensions), the separation of forces into gravity, the strong, weak, and electromagnetic forces, the precise balance between forces, the array of fundamental particles and their ability to form atoms which can engage in chemistry - including the metabolism that keeps living organisms ticking.

The rate at which a parent star moves through its lifetime and how its brightness increases during its Main Sequence phase (the longest part of its lifetime, when it obtains energy through nuclear burning of hydrogen to helium in its core) and what happens when it leaves the Main Sequence will determine the kind of environment that a planet can support. The more massive a star is the brighter and hotter it will be, but the faster it will run through its life-span. The most massive stars rush through their lives and explode as supernovae, fertilising the clouds of gas and dust from which new stars will form with the heavy elements required to build planets like the Earth and for life itself.

The climate of a planet will depend upon its distance from its parent star or stars, its rate of spin, its axial tilt, the way in which its axis precesses in space (like the wobbling of a spinning top). Depending upon circumstances, a large moon might stabilise or de-stabilise axis, with profound consequences for habitability. The planetary system itself must be stable, so that major planets cannot collide and destroy each other or be thrown out into the cryogenic darkness of interstellar space. With too many smaller objects in unstable orbits, collisions with otherwise habitable planets may be too common for life or complex to sustain a foothold. The planet must support geological activity, but be sufficiently quiescent for life to be able to thrive and evolve in shallow seas and on land for hundreds of millions of years. The course of life will owe much to the way in which continents assemble, break up and re-assemble over geological time. The composition of the atmosphere must evolve in a way that nurtures life. There should be a means of accessing nitrogen, essential for life, from the air. Oxygen powers the metabolism of higher life and provides the ozone screen that protects the Earth's surface from intense solar UV. Carbon dioxide provides a raw material for plant growth. It is also a vital greenhouse gas that keeps the mean temperature of the Earth above freezing point. However, it is possible to have too much of a good thing; the release of carbon dioxide by human activity is threatening to carry global temperatures to dangerous levels.

When a frail spider clambers among dew drops on the delicate threads of a silken web that glistens iridescent in the sunlight, this is its back-story.

This kind of eclectic approach has deep historical roots. Philosophers have sought since remote antiquity to draw everything together into unitary view of the entire world. Practical scientific knowledge was sought on a broad front and assembled into syntheses, for example, by Aristotle (384-322 BC), tutor of Alexander the Great (356-323 BC), and his pupils/research associates (notably the botanist and zoologist Theophrastus, c. 371 - c. 287 BC, with whom he travelled).

An ecosystem-level approach to understanding the habitability of planets pervaded the early speculations of the telescopic era and the works of Christiaan Huygens (1629-1695; right painting by Caspar Netscher) of the Netherlands provide a wonderful illustration.

Huygens laid out his speculations about life on other worlds in his "*Κοσηοθεωρος, sive de terris coelestibus earumque ornatu, conjecturae*" or "*Cosmotheoros*," in 1698 (Huygens, 1698; posthumous), which had drafted in the period 1689 to 1690, and which took up much of his final half-decade. He produced his work first in French, but then in Latin, and this version was completed in January, 1695. He died, shortly afterwards in the summer of that year. van der Schoot, J. A. (2011). The Necessity of the Universe. Christiaan Huygens's *Cosmotheoros* (1698) and its philosophical and literary backgrounds: an intellectual testament. Research master thesis. Utrecht University.

Huygens asserted that planetary bodies had been created directly for the benefit of their inhabitants). This idea is now seen (even by scientists with religious beliefs) as rooted in presumption, but his analysis was prescient in many ways. For all that he succumbed to the power of his own imagination in supposing the other planets of the Solar System to be habitable, Christiaan Huygens was certainly correct in recognising that planetary habitability must be understood in terms of an entire ecosystem perspective. He asserted (Huygens, 1698):

"Here then we have found in these new Worlds fields warm'd by the kindly Heat of the Sun, and water'd with fruitful Dews and Showers. That there must be Plants in them as well for Ornament as Use, we have shewn just now. And what Nourishment, what manner of growth shall we allow them? Probably, there can be no better, nay no other, than what we here experience; by having their Roots fastened into the Earth, and imbibing its nourishing Juices by their tender Fibres. And that they may not be only like so many bare Heaths, with nothing but creeping Shrubs and Bushes, we may allow them some nobler and loftier Plants, Trees, or somewhat like them: These being the greatest, and, except Waters, the only Ornament that Nature has bestowed upon the Earth. For not to speak of those many uses that are made of their Wood, there's no one that is ignorant either of their Beauty or Pleasantness." Goldsmith, D. (1980). *The Quest for Extraterrestrial Life. A book of readings*. Mill Valley, California: University Science Books.

Huygens had recognised the existence of what 20th Century ecologists would call a food chain, with plants as the primary producers:

"all the living Creatures of this Earth, whether Beasts, Birds, Fishes, Worms, or Insects, universally and inviolably follow the same constant and fix'd Institution of Nature; all feed on Herbs, or Fruits, or the Flesh of other Animals that fed on them".

The human world was very much part of the picture: "For every Thing here he converts to his own Ends. With the Trees, Stones, and Metals, he builds himself Houses: the Birds and Fishes he sustains himself with: and the Water and Winds he makes subservient to his Navigation: as he doth the sweet Smell and glorious Colours of the Flowers to his delight. What can there be in the Planets that can make up for its Defects in the want of so noble an animal? If we should allow Jupiter a greater Variety of other Creatures, more Trees, Herbs, and Metals, all these would not advantage or dignify that Planet so much as that one Animal doth ours by the admirable Productions of his penetrating Wit."

Taking a leap of a couple of centuries forward, we find this spirit of inquiry alive and flourishing in the works of the celebrated explorer Friedrich Wilhelm Heinrich Alexander von Humboldt (1769-1859).

Public lectures in Berlin in 1827-1828 prepared the ground for von Humboldt's best known work, his *Kosmos* (1845-1862, final volume posthumous). He wrote: "Although the outward relations of life, and an irresistible impulse toward knowledge of various kinds, have led me to occupy myself for many years - and apparently exclusively -- with separate branches of science, as, for instance, with descriptive botany, geognosy, chemistry, astronomical determinations of position, and terrestrial magnetism, in order that I might the better prepare myself for the extensive travels in which I was desirous of engaging, the actual object of my studies has nevertheless been of a higher character. The principal impulse by which I was directed was the earnest endeavor to comprehend the phenomena of physical objects in their general connection, and to represent nature as one great whole, moved and animated by internal forces."

"Beginning with the depths of space and the regions of remotest nebulae, we will gradually descend through the starry zone to which our solar system belongs, to our own terrestrial spheroid, circled by air and ocean, there to direct our attention . . . to its form, temperature, and magnetic tension, and to consider the fullness of organic life unfolding itself upon its surface beneath the vivifying influence of light. In this manner a picture of the world may, with a few strokes, be made to include the realms of infinity no less than the minute microscopic animal and vegetable organisms which exist in standing waters and on the weather-beaten surface of our rocks." **Von Humboldt, A. (1858).** The Project Gutenberg eBook, *COSMOS: A Sketch of the Physical Description of the Universe, Vol. 1*. Translated by E.C. Otte. From the 1858 Harper & Brothers edition. Prepared by Amy Zelmer.

Alexander von Humboldt sounded a warning that rings true today with added urgency. From nearly two centuries in the past, he speaks for our cause: "Man can not act upon nature, or appropriate her forces to his own use, without comprehending their full extent, and having an intimate acquaintance with the laws of the physical world."

Welcome to our new collaborator, Lienkie Diedericks.

I hold an honours degree in analytic philosophy from the University of Cape Town, and am currently completing an MSc in Bioethics at King's College London. My research interests centre around health disparities.

The Ecospheres Project is an opportunity for me to work at the intersection of science and ethics. For me this is the most relevant and exciting junction to be working at in our time.

Having grown up in drought-stricken parts of South Africa (the Northern Cape and the Free State), I developed a profound awareness of the interactions between climate, the natural environment, and human well-being. Recently, both Cape Town and the Free State province have been suffering a crippling drought.

For five days in November 2017, my hometown of Bloemfontein had no access to drinking water because major pipelines had failed due to the build-up of debris associated with chronically low dam water levels. In surrounding communities - including the country's poorest --- incidents of cholera and other communicable diseases have been noted due to a lack of access to water and sanitation. The drought shows no signs of letting up, while other parts of the country, such as KwaZulu Natal, experience recurrent flooding.

I believe that South Africa exemplifies in clear terms the drastic effects that climate change can have on a community with poor infrastructure. It illustrates the urgent need for local governments to make adequate preparations for the effects of climate change.

This has motivated me to work to raise public awareness of the ethical implications of climate change, and aim to show how its effects are detrimental to the health of vulnerable communities.

Seasons in South East England

October 2017

Above: Autumn colours in trees on the hillside above Green Street Green, Kent. Oct 13, 2017.

A dull, dry and warm month.

The Met Office summed up: "*October started with a changeable westerly regime which persisted through the first week, with a succession of frontal systems moving across the British Isles and brighter showery weather in between. Most of the rest of the month was dominated by a warm moist south-westerly type . . . a northerly outbreak on the 29th was followed by a widespread ground frost.*"

The arrival on October 16 of the remnant of Hurricane Ophelia brought oddly-tinged skies to the South East of England, as it drew in smoke from wildfires in Portugal and dust from the Sahara.

Left: In the woodland along Hartley Bottom, Kent, the green of summer was giving way to the yellow of autumn by the first day of October. A Harvest Festival display at St Peter's and St Paul's Church. Ash, Kent. Oct. 1, 2017.

October was the month of fruits, spiders and the Harvest Moon.

Above: Apples ripened on a tree in West Norwood, South London (Oct. 5). Right: Orb web spiders (*Araneus diadematus*) were out in force, as usual for this season. As the Sun sank below the rooftops of South London, it caught the silken threads of a web (Oct. 6). A spider had set up home inside a car, just behind the windscreen (Oct. 9). The Harvest Moon (Oct. 5, this year) is the Full Moon closest to the autumn equinox.

The mean temperature for the UK 11.3°C (1.8°C above the 1981-2010 norm), while England was the UK's warmest country at 12.2°C (1.8°C above the norm). Our region (England SE and Central S) had a mean temperature of 12.7°C (1.7°C above the norm), but East Anglia was both the warmest at 12.8°C and showed the greatest departure from the October norm (1.8°C).

At Heathrow, rain was received on 11 days during the month, but only two days Oct. 12 and 21 saw as much as 2 mm.

The impact of the weather was minimal in our region, but the remnant of Hurricane Ophelia sucked in warm air from the south, together with dust from smoke and it brought with it the highest temperature of the month, 23.5°C at Manston in Kent. On this day, Heathrow saw its highest October temperature of around 22.5°C.

The UK's coldest temperature (-5°C) was recorded in Scotland, at Tulloch Bridge in Inverness-shire. This was also the coldest day at Heathrow October 30, when the thermometer fell almost as low as 3°C. However, the month did not see freezing temperatures in the SE.

Toadstools of *Amanita muscaria* are a familiar autumn sight in Beacon Wood, Kent. These photos, taken on October 7, 2017 illustrate part of the life cycle of the fungus.

The fungus emerges from the ground covered by a white "universal veil," whose remnants are the warty white spots popularly associated with the toadstool. The toadstool grows from a rounded button into a globose form (top left), then flattens out as it grows. More mature specimens in particular may turn orange-brown (below).

Clockwise from upper left: Earthshine on the dark side of the Moon (Oct. 15, 2017). Sunset the same day. A reddened Sun in a pallid sky affected by Sahara dust and smoke from Iberia. Taken on Oct. 17, the day after Storm Ophelia arrived. Wheat in Harvest Festival display at All Saints' Church, Hartley (Oct. 14). A hollowed-out pumpkin Halloween lantern (Oct. 31) gleams in South London. On Brooklands Lake, Dartford a cygnet has yet to lose its juvenile plumage. Oct. 21. Section of image from the NASA/NOAA DSCOVR satellite as Storm Brian swept across Britain. Oct. 21 at 11:43:34 GMT. A sturdy Irish yew (*Taxus baccata* Fastigiata) bends in a strong gust from Storm Brian. Churchyard of St Peter's and St Paul's, Ash, Kent.

Monthly means for SE and central S England. Max. temp.: 16.1°C (1.3°C); min. temp.: 9.2°C (1.8°C). Hours of sunshine: 95.9 (85%). Rain: 31.7 mm (34%). Anomalies re. 1981-2010 norm in brackets. Date obtained from Met Office on-line monthly reports. Heathrow data is obtained from *WeatherOnline*.

Global climate: The fourth warmest October.

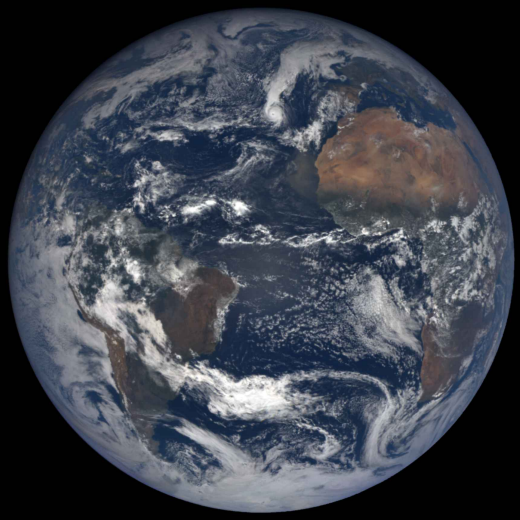
Yet again, although no actual record has been set, another month has joined the ranks of the very warmest. The general long-term increase of global temperature is unmistakeable. The USA's National Oceanic and Atmospheric Administration has stated that October's mean global temperature was 0.73ºC higher than the 20th Century mean of 14.0ºC. "*This value tied with 2003 as the fourth highest October temperature on record since global records began in 1880 . . . The 10 warmest Octobers on record have all occurred during the 21st century, specifically since 2003. October 2017 also marks the 41st consecutive October and the 394th consecutive month with temperatures at least nominally above the 20th century average.***" All the anomalies quoted below are positive.**

Globally, land plus oceans were 0.73 ± 0.14ºC above the mean, (4th, with 2015 as warmest) oceans were 0.63 ± 0.15ºC above the mean (4th warmest; warmest was 2015), whilst the land areas (0.99 ± 0.20ºC) were the 11th warmest on record (2015 was warmest).

In the Northern Hemisphere, land plus ocean was 0.86 ± 0.18ºC above the mean, the 3rd highest on record with 2015 as warmest. The oceans were 0.80 ± 0.14ºC above the norm (4th warmest; 2015 was warmest), while the land (0.95 ± 0.22ºC above the mean), was its 10th warmest (2011 was warmest).

In the S. Hemisphere, the combined land and ocean temperature was 0.60 ± 0.14ºC above the mean (8th warmest; 2015 was warmest). The oceans were 0.51 ± 0.15ºC above the mean (8th warmest, with 2015 as warmest). Meanwhile, temperatures on land in this hemisphere were 1.10 ± 0.17ºC above the norm (7th warmest; 2015 was warmest).

Source: *NOAA National Climatic Data Center, State of the Climate: Global Analysis for October 2017.* Published online. Data is provisional.



Above right: Our world on October 14, 2017 at 13:31:37 GMT. DSCOVR mission. NASA/NOAA.

Hurricane Ophelia reminded us that we live in a closely inter-connected world.

It brought a sepia-tinged sky and reddened Sun to SE England. The media were quick to use the word "apocalypse."

Wild fires (Oct. 13-18) had started in Galicia, Spain and shortly, hundreds of fires burned in NW Spain and N Portugal, fanned by winds from the approaching storm on Oct. 15. In addition to Sahara dust, a smell of burning reached Devon in SW England and black rain, coloured by soot, reached Estonia.

Storm Ophelia hits the British Isles.

Ophelia formed on Oct. 6 from the end of a cold front in the in the NE Atlantic. It became a tropical storm on Oct. 9. By Oct. 14, it was a category 3 Hurricane, the eastern-most feature of that strength ever recorded. It weakened as it moved NE, but it struck Ireland as a hurricane-force extra-tropical storm on Oct. 16 (view above from NASA/NOAA DSCOVR satellite at 12:54:11 GMT).

Wildfires, encouraged by drought, were already raging in Portugal and Spain, and were whipped up by the winds on Oct. 15. The photo below (right) is of a rare fire devil, a mini tornado with flames and winds of up to 160 km per hour, swirling around an ash core. It was taken by a Portuguese crew on Oct. 8, near Arganil, Portugal). Around 7900 individual fires broke out and some 49 people died. View of Portugal on Oct. 7 was from NASA's Aqua satellite. At left: A view from NASA's Terra satellite on Oct. 14, showing the dust plume from the Sahara that Ophelia fed into British skies. NASA image credit: Jeff Schmaltz.

Ophelia's strange skies.

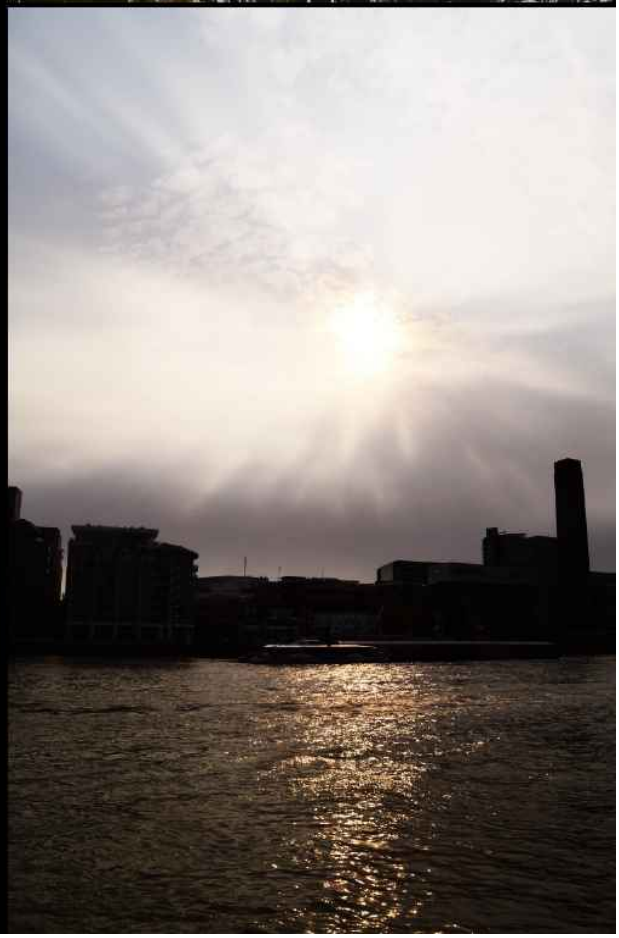
Airborne dust and smoke brought an autumnal tinge to the skies themselves.

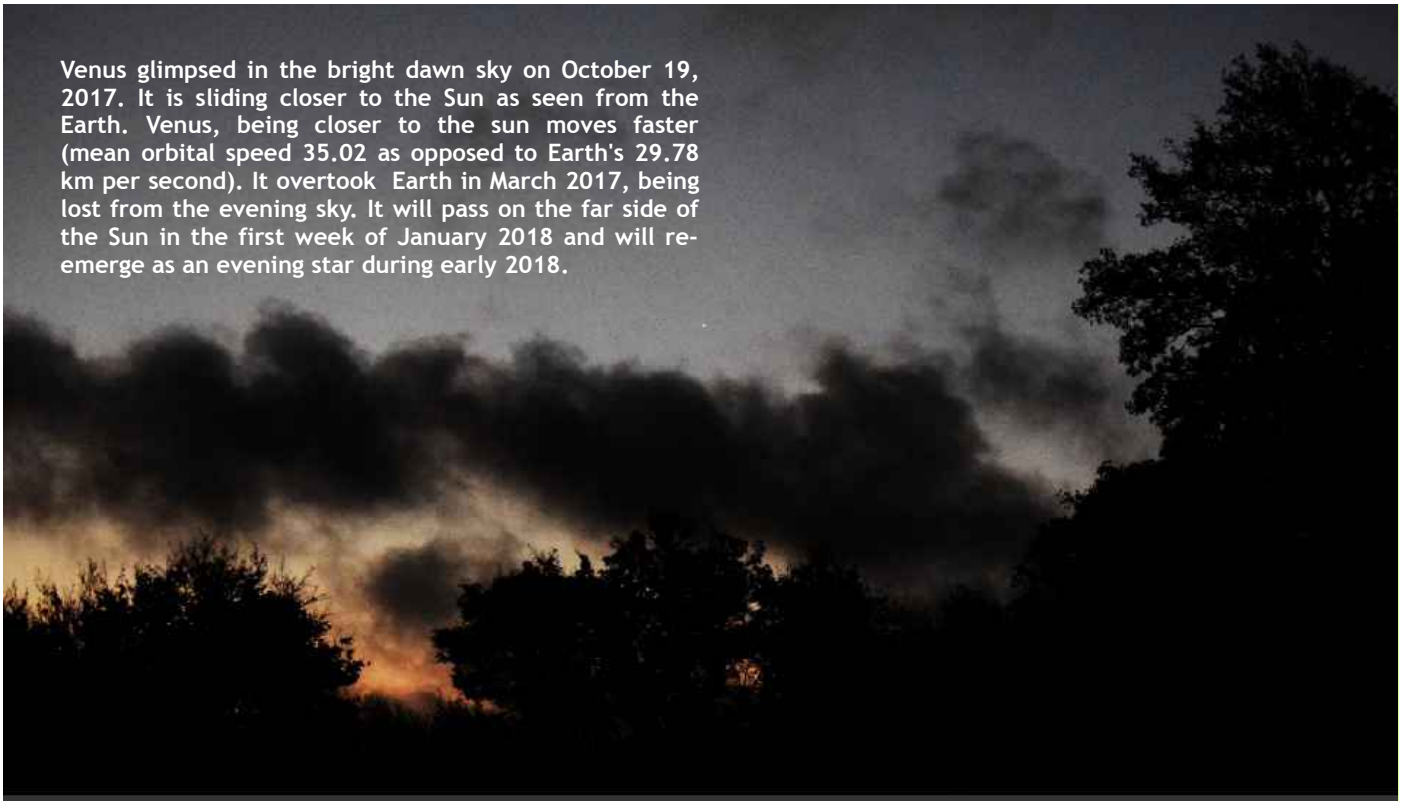
Clockwise from upper left: Sepia skies were seen over London on Oct. 16. The view over the Thames was posted by the London Eye. It was taken at 07:47 AM.

Unusual colours were still visible in the sunset on Oct. 16 (from the hill above Longfield, Kent).

The next morning in New Ash Green, Kent, the skies still retained a dingy hue and the Sun, seen here through trees that were losing their leaves, was distinctly reddish. Up in Central London, the skies had returned to a more normal appearance by Oct. 17. The views below (which have been slightly contrast enhanced) were taken by the Thames at London Bridge. They show beams of sunlight and cloud shadows in the dusty air.

For us, the event was a curiosity and talk of an "apocalypse" was hyperbole. For many in Portugal, contending with out-of-control fires over the summer and autumn, this was reality. In Ireland, 3 people were killed and a third of a million suffered power blackouts due to high winds. Record-breaking gusts of 191 km per hour were felt at Fastnet Rock, which lies off the coast of County Cork.





Venus glimpsed in the bright dawn sky on October 19, 2017. It is sliding closer to the Sun as seen from the Earth. Venus, being closer to the sun moves faster (mean orbital speed 35.02 as opposed to Earth's 29.78 km per second). It overtook Earth in March 2017, being lost from the evening sky. It will pass on the far side of the Sun in the first week of January 2018 and will re-emerge as an evening star during early 2018.

Prime Meridian

Prime Meridian is published by the Ecospheres Project, a trans-Atlantic research and media collaboration. It follows global environmental issues alongside the cycle of the seasons in South East England. It steps back to look at the Earth in its astronomical context and it pursues the search for other habitable worlds.

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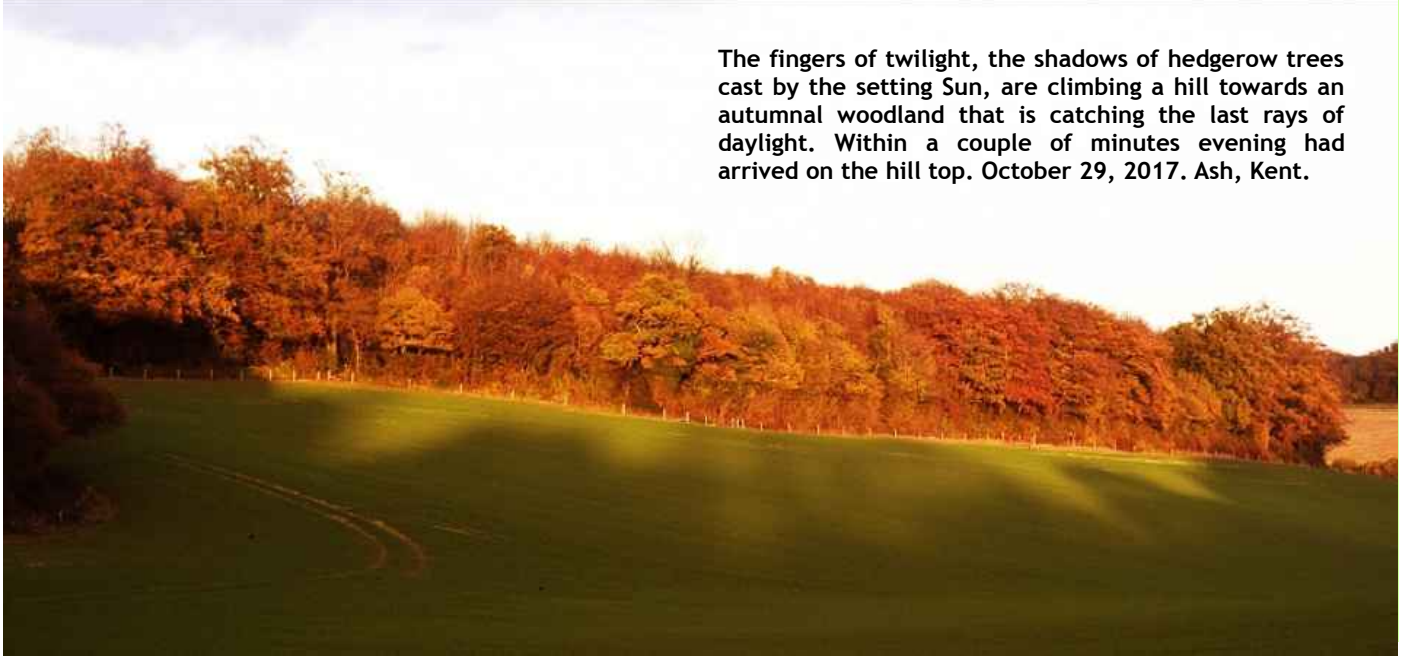

The fingers of twilight, the shadows of hedgerow trees cast by the setting Sun, are climbing a hill towards an autumnal woodland that is catching the last rays of daylight. Within a couple of minutes evening had arrived on the hill top. October 29, 2017. Ash, Kent.