Prime Meridian

(36) February 5, 2015

A newsletter following global environmental issues alongside the cycle of the seasons in Southern England

Above: On a cold February afternoon, the Sun gleams through passing clouds and the bare branches of trees. Feb. 3, 2015, New Ash Green, Kent.

The weather may presently be chill and wintry across much of the Northern Hemisphere, but last year's mean global temperature was 0.69 ± 0.09°C above the 20th Century mean.

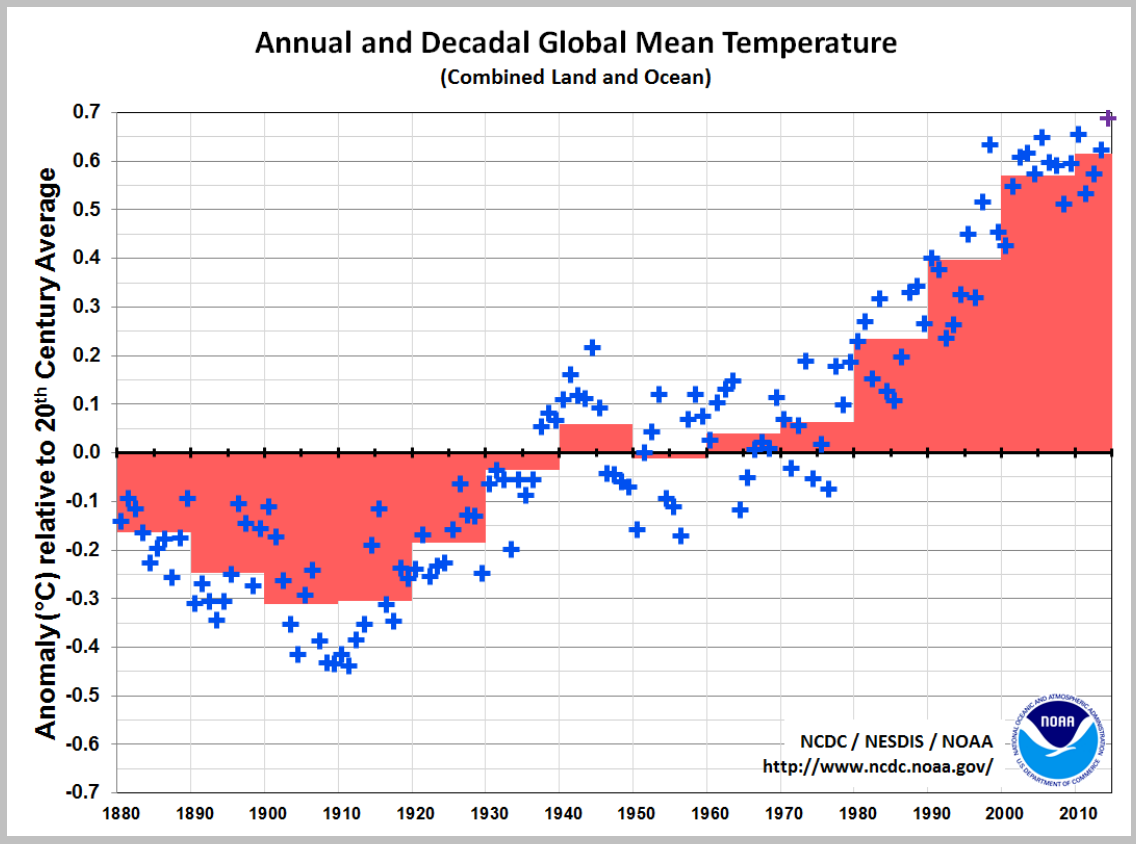
2014 was the world's warmest year on record

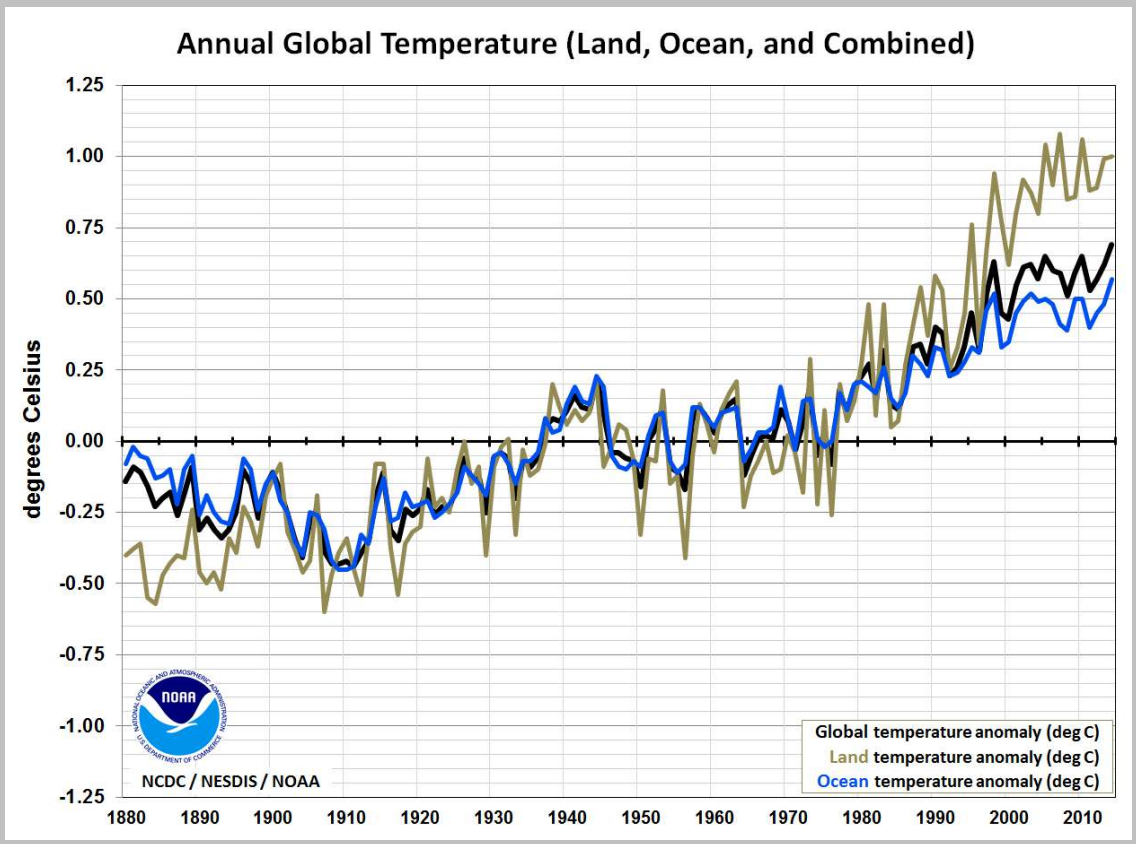
As soon as this conclusion was released by the National Atmospheric and Oceanic Administration (USA)'s, early in the New Year, the news was taken up by the media around the world. 2014 had led the overall long-term trend for mean global temperatures to rise.

According to NOAA "*The year 2014 was the warmest year across global land and ocean surfaces since records began in 1880. The annually-averaged temperature was 0.69°C (1.24°F) above the 20th century average of 13.9°C (57.0°F), easily breaking the previous records of 2005 and 2010 by 0.04°C (0.07°F).*"

Readers of this newsletter will know that record global average temperatures were estimated for no less than six months during 2014, namely May, June, August, September, October, and December, and the year appeared set to be unusually warm.

The 20th C's high of 1998 now rates as the 4th warmest year on record. 2014 (0.69 ± 0.09°C above the 20th C mean) was the 38th year in a row, since 1977, with a higher than average global temperature. It was the first year since 1990, to achieve a record temperature in the absence of El Niño (warm) conditions in the central and east equatorial Pacific.





2014 was also the warmest year according to the independent Berkeley Earth project, but that report noted that 2014's error band overlapped those of 2010 and 2005, the previous joint warmest years, so the status of 2014 was cited as questionable. Overlapping error bands occur also in the NOAA figures. The 2014 anomaly was 0.69 ± 0.09°C versus 0.62 ± 0.07°C for 2010. With that caveat, 2014 led the global temperature rise.

References: NOAA National Climatic Data Center, State of the Climate: Global Analysis - Annual 2014. Published online; data provisional. See also: *The Average Temperature of 2014. Results from Berkeley Earth.*

Can we still keep the greenhouse temperature rise below 2°C? *"a stark transformation in our understanding of fossil fuel availability is necessary."*

There is a widespread understanding that the release of the greenhouse gas carbon dioxide through the burning of fossil fuels must be curtailed sharply if *the* overall rise in temperature by the end of this century is to be kept to no more than 2°C above the level in pre-industrial times. This target, intended to avoid dangerous climate change, has been accepted widely, although some would consider it politically and economically unrealistic.

In a paper published in nature on January 8, 2015, Christophe McGlade & Paul Ekins of the Institute for Sustainable Resources, at University College London have calculated the proportion of carbon reserves that would have to remain unburned if the 2°C target is to be met. According to the Intergovernmental Panel on Climate Change, if we are to have a better than 50% chance to keep the temperature rise under 2°C, carbon release between 2011 and 2050 must be limited to about 870–1,240 x 10^9 tonnes of CO_2. The researchers, who examined the world region by region, concluded that globally a third of oil reserves, half of gas reserves and four fifths of coal reserves should remain untouched, with no exploitation of unconventional sources of oil or the Arctic region. They argued that: "*Although there have previously been fears over the scarcity of fossil fuels* [Yergin, 2009], *in a climate-constrained world this is no longer a relevant concern: large portions of the reserve base and an even greater proportion of the resource base should not be produced if the temperature rise is to remain below 2°C.*"

By "resources" these researchers meant the total quantities of oil, gas or coal that remain in the ground and by "reserves" the quantities that are recoverable under present economic conditions and with present technology.

References: Clarke, L. *et al*. (2014). In *Climate Change 2014: Mitigation of Climate Change* (Edenhofer, O. *et al.*) Ch. 6. Cambridge, UK; Cambridge University Press. **McGlade, C. and Ekins, P. (2015).** doi:10.1038/nature14016. **Yergin, D. (2009).** *The Prize: the Epic Quest for Oil, Money and Power Epilogue*. New York, NY, USA: Simon and Schuster,

Editorial comment:

The recent paper by researchers at UCL about the scale of carbon reserves that would have to remain unburned in order to meet the 2°C target was a valuable and informative study. Back in the political world, of course, major societal and practical challenges would have to be overcome, because the exploitation of natural hydrocarbon resources is bound up, seemingly inextricably, with economic, military and territorial competition between nations and alliances.

We should take note that the immediate and obvious strategic disadvantages of nations depending upon hydrocarbons supplied by rival regimes have failed to drive the development of viable new large-scale energy sources capable of fulfilling civilisation's substantial and growing demands. It should be no surprise that the threat of potential problems caused by climate change in a future some decades distant has likewise failed to do so. We are obliged to question the credibility of statements by policy makers who promise a reduction in CO_2 emissions and/or a transition to renewable energy sources.

Below: Belchatów coal-fired power station, Poland.

While global CO_2 emissions increase each year, recent political events underline how closely the fate of nations has become tied to the use of hydrocarbon fuels and how difficult it would be to disengage from them.

The Europe, the Arctic and the South China Sea are three regions in which the competing interests of major powers are presently colliding.

A pipeline was constructed to bring gas from the former Soviet Union to western Europe in the early 1980s, in the face of vigorous opposition from the USA's Reagan administration, which did not welcome a European dependency on Russian gas. By 2007, 32.6% of total oil import and 38.7% of the EU's total gas import came from Russia (European Commission, 2009). However, Russia has been prepared to use gas supply as a weapon and last year the west imposed sanctions against the Russian Federation in retaliation for it's 2014 annexation of the Crimea and destabilisation of the Ukraine by support for pro-Russian separatists. The European Union has also obstructed Russian plans for a South Stream pipeline that avoided the Ukraine. Russia plans a new route through Turkey. It has pursued deals to sell gas to China and India, welcoming India as a partner in Arctic exploration.

The tempting opportunity of exploiting rich but, as yet, untapped hydrocarbon resources, exacerbates arguments about territorial boundaries in the Arctic. According to a 2013 report *Arctic Oil and Gas* from consultants Ernst & Young, the Arctic probably has 20% of the world's undiscovered but recoverable oil and natural gas resources. The report built upon the first attempt to estimate the total Arctic hydrocarbon resources by the US Geological Survey (USGS, 2008). The Ernst & Young document noted (page 2): "*Approximately 61 large oil and natural gas fields have been discovered so far within the Arctic Circle — 43 are in Russia, 11 in Canada, 6 in Alaska and 1 in Norway.* [US Department of Energy, 2009]".

According to the USGS (US Dept. Interior/USGS, 2008) the Arctic may harbour 13% of the world's undiscovered oil reserves and up to 30% of undiscovered natural gas reserves. Russia is the closest country to more than half of the Arctic resources. Total Arctic resources amounted to 90 x 10^9 barrels of oil, 47.26 x 10^{12} m^3 (1,669 trillion cubic feet) of gas, and 44 x 10^9 barrels of natural gas liquids, all adding up to 412 x 10^9 barrels of oil equivalent. Denmark (through Greenland) and Russia both claim the undersea Lomonsov Ridge as their continental shelf, whilst the USA and Canada dispute boundaries in the Beaufort Sea.

In the South China Sea, the People's Republic of China has claimed offshore territory which extends over 1,200 km from its own coast, into the zone between Malaysia and Vietnam, encompassing hundreds of islands and reefs, mostly in the Paracel Islands and Spratly Islands. The dispute involves Vietnam, Malaysia, Taiwan (seat of the Republic of China and claimed by the People's Republic of China), Brunei, Indonesia and the Philippines. There has been a long and complex series of incidents, including the use of naval vessels, between China and Vietnam. Last year, China set up an oil rig in disputed territory, collisions have taken place with Vietnamese vessels, the Chinese navy shadowed Indian navy vessels and its air force shadowed US surveillance planes. Vietnam has been in talks with India about oil exploration and China has protested. Estimates of the actual quantity of hydrocarbon resources here are hampered by limited exploration surveys. [See also *Economist* Jan. 26, 2015]

The possibility of China seeking control over shipping lanes has raised concerns since, as estimated by the US Energy Information Administration (2013), "*more than half of the world's annual merchant fleet tonnage passes through the Straits of Malacca, Sunda, and Lombok, with the majority continuing on to the South China Sea. Almost a third of global crude oil and over half of global LNG* [liquified natural gas] *trade passes through the South China Sea, making it one of the most important trade routes in the world.*"

References: European Commission (2009). *Energy Dialogue EU-Russia. The Tenth progress Report.* November 2009. **Ernst & Young (2013).** *Arctic oil and gas. The Economist* (2015). The South China Sea: Oil On Troubled Waters. Jan. 26. 2015. **U.S. Department of Energy, Energy Information Administration (2009).** *Arctic Oil and Natural Gas Potential.* October 2009. **U.S. Department of the Interior/U.S. Geological Survey (2008).** *Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle.* May 2008. **U.S. Energy Information Administration. (2013).** South China Sea. Updated February 7, 2013 (Notes).

Above: Protest notice was fixed over the door of a public house in Brixton, London, UK.

A predictable response to hydrocarbon dependence has been for nations to exploit their own resources, notably through fracking, which can extract oil from shales rather than from classic geological oil reservoirs. This technique involves hydraulic fracturing - pumping water, sand and various chemicals (there has been much pressure on companies to disclose all their ingredients) into underground rocks to break them up and extract oil.

The NASA image at left (2012) shows the North American continent at night. The bright area glowing in the emptiness of the Great Plains in North Dakota (inside the square) is produced by hundreds of rigs burning off excess natural gas which has emerged with the oil extracted from shales by fracking. It could not be transported by the existing pipeline system and the industry finds it cheaper to burn off the gas than to construct pipelines with higher capacity.

The Department of Mineral Resources in North Dakota has stated that no less than 29 % of the natural gas is burned off (enough to heat half a million homes, say environmentalists). Drillers are able to do this for a year without incurring financial penalties and extensions are available.

Around 7 years ago, the area grew wheat, alfalfa and oats, but since then, 150 companies have moved in to exploit oil deposits from the shale of the Bakken Formation, which is actually nowhere exposed on the surface.

The formation was described by Nordquist, J. W. (1953). *Mississippian stratigraphy of northern Montana*, Billings Geological Society, 4th Annual Field Conference Guidebook, pp. 68-82). It was laid down in the later part of the Devonian Period and the early part of the Mississippian Period, it consists of a lower and upper shale, rich in carbon compounds, which formed in deeper, oxygen-poor waters and dolomites (magnesium-rich limestone) which formed in shallower waters with more oxygen and which contains an oil reservoir.

This fracking boom illustrates in stark terms the dilemma which we face as we attempt to balance the long-term health of the global environment against shorter-term economic needs. Whatever the dangers of CO_2 release, or associated environmental hazards, the fracking industry has brought economic growth, employment, opportunity and upward economic mobility. North Dakota has become the USA's second most productive oil state after Texas and by the end of 2014, it was producing about 911,000 barrels a day, compared with 660,000 barrels in 2013.

There have been repercussions of the rapid growth in fracking. Opec (Organization of the Petroleum Exporting Countries) has brought down oil prices drastically, in an attempt to undermine the economics of fracking.

Flagging up energy security as of "*utmost importance*," Nato chief, Anders Fogh Rasmussen has recently and controversially accused Russia of encouraging the movement against fracking in order to protect its role as a gas supplier.

Fracking, evidently, offers no escape from the fierce international competition over access to hydrocarbon supplies.

Above: The Sendai region of Tōhoku, Japan, in the wake of the 2011 tsunami. U.S. Navy photo. 110312-N-0000X-003.

"An underwater landslide the size of Paris combined with waves from the quake to deal the coast an extra-deadly blow." Pease, R. (2014). *Science* 346: 18.

A massive tsunami produced by an offshore magnitude 9 earthquake struck Japan on March 11, 2011 (05:46 UTC). The inundation resulted in 18,000 deaths and there were widespread breakdown of water and electricity supplies. In the picture above, smoke is billowing from the Nippon Oil refinery. Water rose over the sea walls in the vicinity of the Fukushima nuclear plants and Fukushima Daiichi suffered three explosions. A release of radiation followed, resulting in a state of emergency being declared and hundreds of thousands of people being evacuated. The incident prompted recriminations about inadequate protection and widespread concern in Japan about the safety of nuclear power plants. A new study (reviewed by Pease, 2014) by Stephan Grilli of the University of Rhode Island and co-workers has asked how it was that whilst parts of the coast were hit by a 10 m tsunami, the 100 km long mountainous section of coast (Sanriku) was struck by enormous waves 40 m high. Their controversial conclusion was that 170 km from the shore, near the northern end of the 2011 rupture, a 2 km thick slab measuring 20 x 40 km slid 0.3 km down the side of the Japan trench. This took place in water around 4.5 km deep. Making accurate forecasts of when earthquakes will occur is problematic enough, but giant landslides are much more unpredictable, If this is what actually happened in 2011, then it is going to be extremely difficult to predict when gigantic tsunamis are likely to threaten communities along this part of the coast.

2025: 1.8 billion people could face water scarcity and for two-thirds of the world's population the demand for clean water may outstrip the supply. Elliason, J. (2015). *Nature* 517: 6.

Writing in an issue of *Nature* published on New Year's Day, Jan Eliasson, Deputy Secretary-General of the United Nations, sketched out the looming problems of water supply and urged diplomatic moves to ease the problem. Eliasson, who launched the 2013 Call to Action on Sanitation, provided disturbing statistics. Water access had been improved for 2 billion people by the push for the Millennium Development Goals, but 750 million people do not enjoy safe drinking water. About 80% of waste water enters rivers, lakes and the ocean untreated. 2.5 billion people do not have adequate sewage disposal. About 2 million children under the age of 5 die each year because of poor water. Yet demand for water could soar 40% by 2050. There is a growing prospect of nations competing for water, but "*it would be a mistake to get caught up in 'water-war' rhetoric. Certainly, as freshwater shortages become increasingly acute, the threat of violence over water is a real one. But we must not lose sight of the opportunities that water offers as a source of cooperation.*"

Seasons in South East England

December, 2014

Above: The late afternoon Sun, sitting on the horizon, gleams through the trees of a hedgerow dividing two fields near West Kingsdown, Kent. Dec. 6, 2014.

Mild and wet, but with frosty episodes.

The mean temperature for the UK was estimated provisionally as 4.4°C (0.5°C above the 1981-2010 mean. The UK's Met Office reported that: "*For much of December the weather was from the west, giving milder, wetter spells, particularly in the north and west, interspersed by drier brighter days. The moist, mild Atlantic air gave some notably high temperatures but there were colder spells too from 3rd to 14th and more especially from 27th to 30th.*" Also, despite unsettled weather, rainfall was generally lower than normal in the south and east.

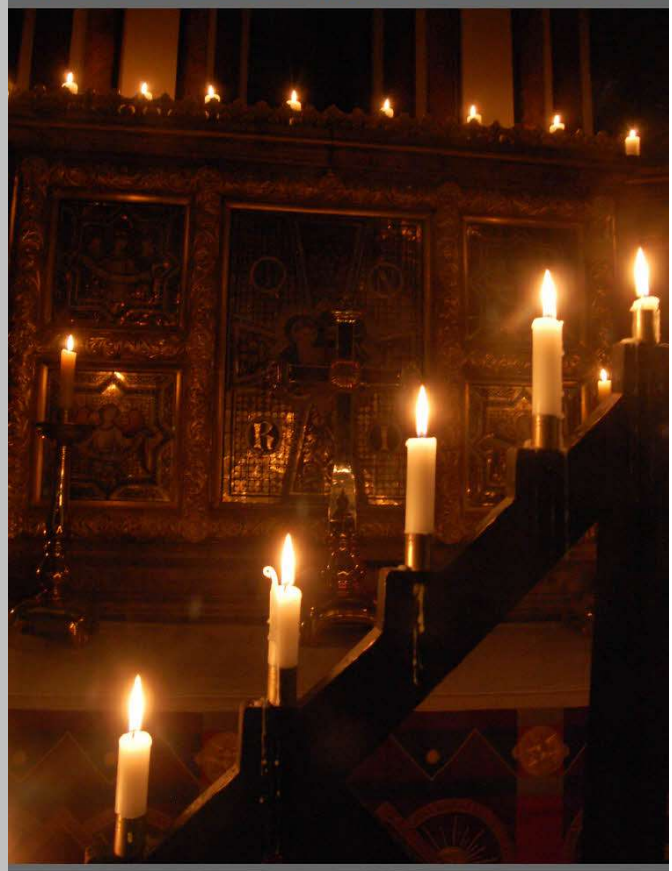
According to WeatherOnline, at Heathrow in Greater London, top temperatures hovered around 8°C between Dec. 1 to 3, then fell to 5°C on Dec. 4. between Dec. 8 and 16 between 7°C and 10°C. Meanwhile, the lowest temperatures at Heathrow fell below freezing point on Dec. 6, 9 and 14.

Left from top: Choristers at King's College London, Advent service Dec. 4, 2014. A wet evening in Trafalgar Square, London. The Christmas tree is an annual gift from Norway; National Gallery in background (Dec. 4). The mellow light of the setting Sun catches the hedgerow near West Kingsdown (Dec. 6). Below: In a cold pocket behind the hedgerow, frost had coated grass and plantain.

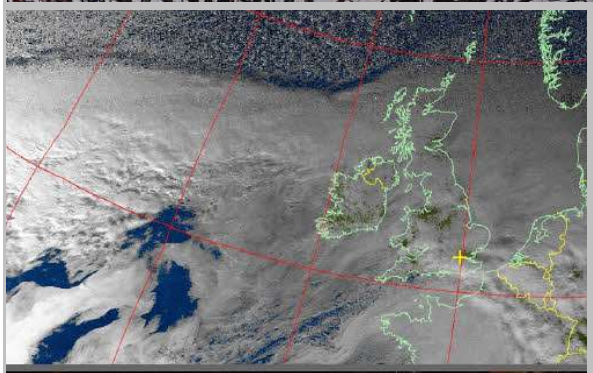
Dec. 9 saw a gust approaching 113 km per hour at Needles Old Battery (Isle of Wight) and on Dec. 12, strong winds and rain spread across the south, with a gust of 142 km per hour at Needles Old Battery. The same day, Heathrow, received 10 mm of rain. 3 mm of rain were received at Heathrow on Dec. 16 and 5 mm on Dec. 17.

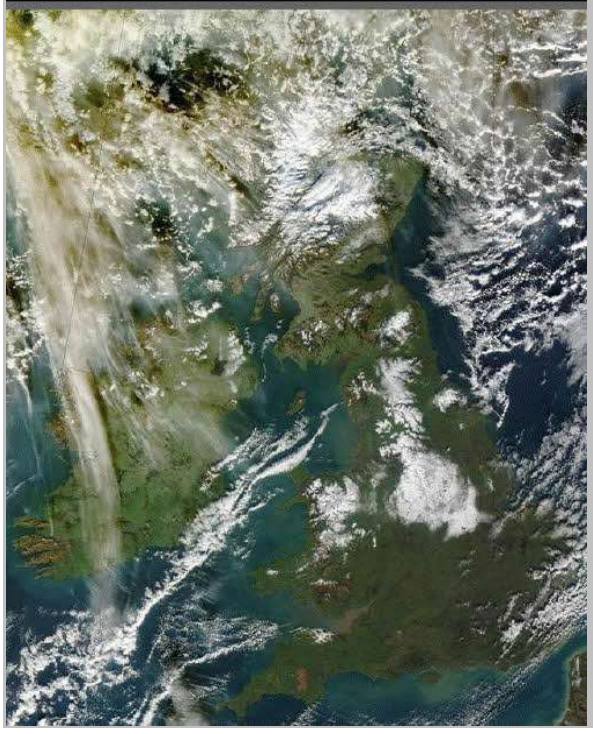
There was a warmer spell between Dec. 17 and 19 with almost 14°C on Dec. 18. After Dec. 20, temperature rose again. On the day of the winter solstice, Dec. 21, London saw a mild temperature of 14°C according to the Met Office, less than 10°C was quoted by WeatherOnline for Heathrow, which saw a highest temperature approaching 14°C on Dec 22 (when the UK's maximum temperature of 16.0°C was recorded at Prestatyn, Denbighshire. The temperature at Heathrow managed to reach 12°C on Christmas Eve, but failed to reach 5°C on Dec. 27 (when the UK's minimum temperature of -9.0°C was recorded at Cromdale, Moray). Snowfall was not expected on Christmas Day in the south, although Heathrow received 8 mm of rain on Dec. 26. Heathrow saw a maximum temperature of 5°C on Dec. 27. The highest temperature managed around 6°C from Dec 28 and Dec 30, reaching almost 8°C on New Years Eve. The lowest temperatures were chilly. They fell below 0°C on Dec. 26, below -3°C on Dec 29 and about -4°C on Dec. 30 and 31.

The UK Met Office summed up: "*The moist, mild Atlantic air gave some notably high temperatures but there were colder spells too from 3rd to 14th and more especially from 27th to 30th. Although it was unsettled for much of the time, rainfall totals were mostly below average in the south and east and in these areas there was plenty of winter sunshine. On Boxing Day* [December 26] *there were some snowfalls at lower elevations in Wales in northern England, followed by a notable anticyclonic spell toward the New Year. This brought clear skies, hard frosts and the lowest UK temperature readings of the calendar year.*"



Right, from top: Oak tree, caught in the light of sunset, still retains many of its leaves. Dec. 7. Belair Park, S. London. Candle light carol service, chapel of Kings College London on Dec. 9, 2014. Frost on sycamore seeds and fallen leaves in a S. London gutter (flash) on the cold night of Dec. 14. Below: Bare field near West Kingsdown, Kent. December 14, 2014.





Above: Thrushes (*Turdus*) are in the process of picking an ornamental *Sorbus* street tree clean of its white berries. Dec. 20, 2014. Left, top to bottom: The weather over the UK on the day of the winter solstice, Dec. 21. Taken by the NOAA-19 satellite at 13:58 GMT. Courtesy Geoff Hamilton. Midnight Mass as Christmas Day arrives, All Saints, West Dulwich, South London. The lower image, obtained by NASA's Terra satellite shows snow cover over the mountainous areas of Britain. 11:00 GMT on December 28, 2014. Source for weather summaries: Met Office online reports. Heathrow data from WeatherOnline.

SE and central S England, mean max. temp.: 8.7°C (0.9°C); mean min. temp.: 2.2°C (0.2°C). Hours of sunshine: 76.1 (149%). Rain: 55.9 mm (67%). Anomalies re. 1981-2010 norm in brackets. Source UK Met Office.

Global climate: We closed 2014 with the warmest December on record.

The monthly report from the USA's National Oceanic and Atmospheric Administration has confirmed that December 2014 saw the highest mean global temperature in a record beginning in 1880.

For the world's land and ocean taken together, the mean temperature for December 2014 was 0.77 ± 0.07°C above the 20th Century mean of 12.2°C. Land areas saw the 3rd warmest temperature (2003 and 2006 were joint warmest) at 1.362 ± 0.12°C higher than the norm, whilst the world's oceans, taken by themselves, also ranked 3rd after (1997 and 2009 were joint warmest) with a mean temperature 0.55 ± 0.04°C above the norm.

In the Northern Hemisphere, the combined mean temperature for land and ocean was 0.99 ± 0.08°C above the norm. This tied for first place in the record with 2006. Land areas, at 1.58 ± 0.11°C above the norm, ranked 5th with 1939 as warmest. Meanwhile, the oceans, at 0.64 ± 0.07°C above the mean, were the warmest on record for December.

Above: A muddy track through the upper part of Sydenham Hill Wood on Dec. 27. Ice in puddle, Belair Park, S. London on Dec. 29. On the final day of 2014, the tower of St. Peter's and St. Paul's Church appeared through the bare branches of trees and a lesser celandine (*Ranunculus ficaria*; taken with flash) was flowering by the wall to the churchyard. Ash, Kent.

The Southern Hemisphere's combined land and ocean temperature was 0.54 ± 0.06°C above the norm, making this the 5th warmest December on record for this hemisphere (with 1997 retaining the record). Land areas were 0.77 ± 0.12°C above the norm (the 10th warmest December on record (2012 and 2013 hold the record), while the oceans (0.50 ± 0.04 above the norm) were the 4th warmest (warmest was 1997). Source: NOAA National Climatic Data Center, State of the Climate: Global Analysis for December, 2014. Published online [data provisional].

The UK's warmest year on record – see next page.

Below: December 7, 2014. Brown leaves cling here and there to the branches of trees in Belair Park, South London.

Editor M. J. Heath. Editorial assistance, Penelope Stanford.

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2014 has been cited by the UK's Met Office as the warmest year in Britain since 1659.

The Met Office reported that with the exception of August, every month of 2014 was warmer than the average.

The mean temperature for the year was 9.9°C. This was 1.1°C above the average for the period 1981-2010.

The next warmest year had been 2006, which had been 9.7°C above the mean. No individual month achieved record warmth, but every month, apart from August, had a mean temperature that was above average. The number of air frosts was the lowest in a series from 1961.

The UK rainfall total for 2014 was 1,297 mm (112% of the 1981-2010 average), making it the 4th wettest year in a record which began in 1910.

It was wetter than normal in many areas, in particular, SE England and E Scotland. SE England saw its 3rd wettest year, to which January and February made significant contributions.

Above: Similar views across Dulwich and Sydenham Hill Woods, Southwark, South London, taken at four different dates during 2014. The top view was taken on March 22, before most of the leaf buds had opened. About a month later, on April 26, most of the trees were cloaked with fresh green foliage. On September 13, the trees bore the dense and darker foliage of late summer. By November 15, the woods had been transformed by the yellows of autumn.

The Met Office noted that: *"The most extreme weather events of the year were the winter storms of January and February, which brought damaging winds, with inland and coastal flooding. In comparison, the rest of the year was relatively quiet. Summer 2014 brought some fine weather - particularly in June and July. There were no major heat-waves but several instances of torrential summer downpours causing localised flash-flooding, for example across parts of England on 19 to 20 July. On 10th August ex-hurricane Bertha brought strong winds, heavy rain and flooding to north-east Scotland and a major winter storm affected the north of the UK in early December."*