Bite-size Climate Science

SALISBURY ECO-HUB ALLIANCE

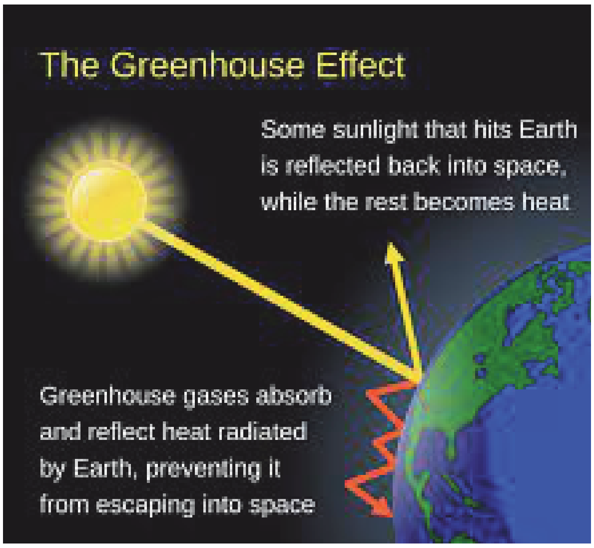
The Greenhouse Effect

What's going on in our atmosphere?

Our atmosphere - the thin envelope of gases which surrounds the Earth - is made up of a number of different gases, which each have different properties. The two main ones are nitrogen (about 78%) and oxygen (around 21%). Other gases make up a much smaller proportion of the whole, and their concentrations are measured in parts per million (ppm): a concentration of 100 ppm is equivalent to one hundredth of 1% of the gas molecules in the atmosphere.

Although the amounts of these gases are tiny, they can still have a big effect. A number of them, which we now refer to as Greenhouse Gases (GHGs), have the effect of making our planet warmer than it otherwise would be without them. Because the concentrations of these GHGs have increased over the past 200 years, and are continuing to do so, our planet is getting hotter and hotter. This is the phenomenon known as Global Warming, which is changing the weather patterns all around the world, and is therefore also known as Climate Change.

What is the Greenhouse Effect?



Our Earth is constantly being warmed by the heat of the sun. Because the Earth is rotating, at any one place on the Earth we experience that heating in the daytime when we are facing towards the sun and cool down again at night, because the Earth is also constantly radiating heat back out into space.

The GHGs in the atmosphere absorb some of the heat the Earth is radiating outwards, and themselves radiate heat in all directions, so that some of it comes back down again to the Earth's surface. In this way, they trap heat and act a bit like the glass in a greenhouse, which is why this is called the Greenhouse Effect.

If there were no Greenhouse Gases in the Earth's atmosphere, our planet would be very cold indeed. Most of the heat from the sun would escape back into space, and the average surface temperature would be around -18^{o}C. The Earth would be a ball of ice. With increasing Greenhouse Gases in the atmosphere, less of the sun's heat is escaping, so the Earth is now heating up to record levels, and will continue getting hotter.

Why are Greenhouse Gases increasing?

Since the start of the industrial revolution, around 250 years ago, we have been burning ever-increasing amounts of fossil fuels - coal, oil and natural gas. This releases carbon dioxide (CO_2) into the atmosphere. CO_2 is a powerful Greenhouse Gas which remains in the atmosphere for 300 to 1,000 years, and CO_2 levels have increased by 50% from their relatively stable pre-industrial level, from below 280 ppm in 1750 to over 420 ppm now, and are still going up faster than ever.

Water vapour, H_2O, also acts as a Greenhouse Gas. As surface temperatures rise, more water evaporates from the oceans and multiplies the effect caused by CO_2. Increased water vapour also disrupts weather patterns, causing storms and flooding in some places and droughts in others.

Methane and other Greenhouse Gases

Although CO2 and water vapour are the most abundant GHGs, there are a number of others which also add to the problem. The most significant of these is methane.

Methane is a naturally occurring gas produced by the breakdown of plant material. It may come from natural sources (such as 'marsh gas' from swamps and bogs), from agriculture or landfill sites, or from the digestive systems of animals (as from belching cattle or human farts). Along with butane and propane, it is also a component of the 'natural gas' we use for cooking and heating. In the upper atmosphere, each molecule of methane is around 85 times more damaging as a GHG than one of CO_2 over 20 years, although it breaks down in 10-12 years (compared to up to 1,000 years for CO_2).

Governments have promised to reduce methane emissions along with those of CO_2, but probably the greatest danger comes from huge quantities of prehistoric methane frozen in the ground in Arctic regions. As the Earth warms and this permafrost thaws, this methane is increasingly being released to the air, and could lead to an unstoppable surge in global warming.

Other GHGs include nitrous oxide (N_2O, largely from agricultural fertilisers) Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). The last four of these are all man-made gases used in industry. HFCs and some PFCs are used as refrigerants in place of CFCs, which were banned under the 1990 Montreal Protocol because of the effect they had of depleting the ozone layer. Ozone (O3) also acts partly as a GHG, but has a more important beneficial role of shielding the Earth from harmful ultraviolet radiation.

Although quantities of these other GHGs are small, their combined effect is significant. Scientists have calculated their effects over 100 years compared to CO_2 so that emissions can be expressed as CO_2 equivalent gigatonnes (Gt CO_2e). In 2019 total global CO_2 emissions were 40.53 Gt, but total GHG emissions were 18.67 Gt CO_2e higher when other GHGs were included.

What the science tells us

According to the 2021 Intergovernmental Panel on Climate Change (IPCC) report, to meet the Paris target of keeping Global Warming to no more than 1.5^{o}C, we have to reduce global CO_2 emissions steadily by 45% by 2030, and to net zero by 2050.

Put another way, this means that if total global CO_2 emissions from 2020 to 2050 can be limited to 300 Gigatonnes (Gt) - an average of 10 Gt per year - we will have an 83% chance of meeting the target: if that total reaches 500 Gt, our chances will be only 50-50.

CO_2 emissions in 2021 were at least 36.3 Gt, and are still rising, so to meet the target we have to drastically cut our use of fossil fuels. Most of our remaining carbon budget will have to be devoted to creating the renewable energy infrastructure we will need for a sustainable, pollution-free future after 2050. If we fail to do this, then climate change will be spiralling completely beyond our control.

What can we do?

We cannot undo the damage which has already been done. Average temperatures are now 1.09^{o}C above pre-industrial levels and will go on rising even if we could cut emissions to zero tomorrow.

The best we can hope for is to limit that rise to 1.5^{o}C. To do that we have to drive and fly far less, insulate all our buildings, and reduce our fossil fuel consumption to near zero as quickly as possible.

We have to learn to consume less, and build the capacity to generate all the energy we need from clean renewable sources.

It's a huge task, but it can be done, and it's one at which we cannot afford to fail.

For more information, see the other leaflets in our new Bite-size Climate Science series.

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