Revolution changed the climate

In the first in a series of four articles about climate change and agriculture in New Zealand, Dr Harry Clark of the New Zealand Agricultural Greenhouse Gas Research Centre lifts the lid on the origins and science of climate change, explaining how human activities are dramatically increasing concentrations of greenhouse gases and triggering major environmental changes.

ABOUT 250 years ago a revolution began in Europe that would drastically alter the lives and lifestyles of millions, eventually billions, of people worldwide.

Clever industrialists discovered that by extracting and burning fossil fuels like coal and oil they could power machines capable of producing goods and food on an unprecedented scale.

Soon they discovered the same fuels could drive vehicles of previously unimaginable might, carrying their goods to market faster and in larger quantities than ever before.

Fortunes were made.

The population exploded.

Forests made way for towns, roads and railways and farms to feed the hungry masses.

Little did those pioneering industrialists know their revolution would reverberate in a very different way, centuries later.

The unconstrained burning of fossil fuels and rapid deforestation that characterise the industrial era have significantly disrupted the cycles of elements like carbon, nitrogen and phosphorus, which are found naturally in the earth and atmosphere. Atmospheric concentrations of some of these elements in their gaseous form – named greenhouse gases or 'GHGs' – have increased rapidly, causing the atmosphere to warm up and our climate to change.

Average and extreme temperatures around the planet are rising, resulting in reduced snow cover, melting glaciers, extended growing seasons and shifting rainfall patterns.

At the same time the oceans are warming, causing water volume to expand and sea levels to rise.

The implications for our natural world and for humanity are significant.

Changes to the climate have occurred naturally before.

They've triggered massive environmental changes.

The last time the polar regions of Earth were at least 2^{o}C warmer than now for an extended period was about 125,000 years ago when sea levels were about six metres higher than today.

That's how we know the impacts of human-induced climate change are likely to be very serious.

And greenhouse gases haven't been as high as they are now for at least 800,000 years, possibly even several million years.

In response, 185 countries including New Zealand have signed an agreement that commits them to setting emissions-reduction targets. The goal is to keep the global temperature increase to well below 2°C and pursue efforts to limit the warming to just 1.5°C.

So, what are the main greenhouse gases, where do they come from, what effects do they have and how much have they increased since pre-industrial times?

There are seven recognised greenhouse gases.

Three of them account for most of NZ's emissions. They are carbon dioxide, methane and nitrous oxide.

In NZ carbon dioxide is released from the use of fossil fuels.

Our methane and nitrous oxide emissions come mainly from agriculture and are described as biological gases because they're by-products of microbial processes.

Globally, all these gases exist at extremely low concentrations in the atmosphere.

For example, carbon dioxide is about 400 parts per million (ppm) and methane is less than 2ppm.

The problem is they're highly effective at trapping heat and their concentrations are increasing rapidly.

Carbon dioxide has increased by about 46% since the beginning of the industrial revolution.

In the 10,000 years prior, its concentration was less than 300ppm. We know this from ice core measurements. Most of the increase is from burning fossil fuels and deforestation.

Carbon dioxide is a big problem because every emission stays in the atmosphere for many centuries and the warming continues for millennia. Carbon dioxide is the dominant greenhouse gas from human activities driving climate change.

Methane has more than doubled in the same period from less than 1ppm to nearly 2ppm now.

Globally, methane is the second-most important greenhouse gas contributing to the observed increase in global temperatures. Not all of the increase is from agriculture. Fossil fuel exploration and extraction also release methane.

While methane is present in much lower concentrations than carbon dioxide every tonne emitted traps heat 28–34 times more effectively when considered over a 100-year timeframe.

On average, methane lasts in the atmosphere for about 12 years, but its warming effect continues at a low rate for centuries.

Nitrous oxide is a tiny component of the atmosphere – less than one-thousandth as abundant as carbon dioxide – but every tonne emitted is 298 times more effective at trapping heat than carbon dioxide over a 100-year timeframe.

Nitrous oxide has increased about 16% since pre-industrial times from the burning of fossil fuels and wood, increased use of nitrogen fertilisers and increasing amounts of animal manure.

It lasts in the atmosphere for over a century and the warming it causes continues for several centuries.

Scientists around the world are working hard to find ways of reducing emissions of all greenhouse gases. Most of the global effort is centred on carbon dioxide.

In NZ, an agriculture-dominated economy, a large research effort is focused on reducing methane and nitrous oxide from livestock farming operations.

The challenge is to find ways of reducing emissions without compromising the viability of individual farming businesses or adversely affecting the national economy.

In the next issue I'll take a closer look at methane – probably the most misunderstood of NZ's three major greenhouse gases.