



*INSERT: Dr Mike White at replanting site. RIGHT: The forest at Akasusa is severely impacted by climate change. © Photograph courtesy Dr Michael White*

# CLIMATE CHANGE

by Dr Michael White

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Modern *Climate Change* is being driven by people and our daily activities, especially burning fossil fuels. Some people deny that we have anything to do with causing global warming, but the science is crystal clear: it is basic chemistry and physics. Coal, gas, diesel and other fuels are hydrocarbons. The hydrogen burns and carbon combines with oxygen to produce carbon dioxide (CO<sub>2</sub>): it is that simple. The greater the concentration of CO<sub>2</sub> in the atmosphere, the warmer our world becomes.

Sunlight arrives as ultraviolet (u/v), which keeps our world warm enough to live on (-14° Celsius / 7° Fahrenheit without sunlight). Earth radiates heat energy back out as infra-red, but this cannot pass through the cloud layer and most is reflected back down again. This is the *greenhouse effect*. Water vapour is also a greenhouse gas (GHG); there are a few others such as nitrous oxide and methane.

**Carbon Footprints** are a way to show the impact of a person, organization or particular activities. We calculate this by multiplying the **amount of fuel** used and the appropriate **Emissions Factor**. We can report this as **kgCO<sub>2</sub>e** (e stands for equivalent, so we can use the same values for other GHGs). Some examples are:

<u>1 litre of fuel (equals 0.264 gallons)</u>	<u>kgCO<sub>2</sub>e</u>
Jet fuel	3.5
Diesel	2.7
Gasoline	2.3
Propane	1.5

It is obviously harder to figure out your Carbon Footprint for things like air travel, or buying power from a coal-fired utility. The important message is to understand your personal contribution and try to reduce it. We have 7.7 billion people on our planet now: five times more than a century ago. We are all part of the global climate problem. Just about everyone uses fuel in some way.

Historically, the USA has been the world's largest polluter and by its own admission the Pentagon is the largest producer of GHGs in the world (Crawford 2019).

<https://watson.brown.edu/costsofwar/files/cow/imce/papers/2019/Pentagon%20Fuel%20Use,%20Climate%20Change%20and%20the%20Costs%20of%20War%20Final.pdf>

One way to think about the greenhouse effect is that every CO<sub>2</sub> molecule added to the atmosphere worsens the

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problem, every molecule saved eases it. Carbon dioxide mixes easily and travels world-wide in about five days; it can persist for hundreds of years. Methane is worse but shorter-lived. The measurement we use is *parts per million* (ppm).

Step back into history for a moment. At the start of the Industrial Revolution in 1750, when Scottish inventors made steam-driven machines powered by coal: atmospheric CO<sub>2</sub> was 280 ppm. In 1900 CO<sub>2</sub> concentration was 310 ppm: an increase of only 30 ppm in 150 years that included the first public railroad (Stockton-Darlington 1825); Karl Benz's motorcar (1855); and Rudolph Diesel's compression ignition engine (1899). The Wright Brothers powered-flight came along in 1903. In May 2019 global CO<sub>2</sub> concentration is **415 ppm**.

So what can we do about it? Deep Decarbonisation can be accomplished by:

- Use less fuel / plan journeys better and avoid needless travel.
- Switch to less polluting fuels / changing from diesel to propane, biodiesel, or even better electric vehicles.
- Remove CO<sub>2</sub> from the atmosphere and ocean / tree-planting is a simple method. Carbon capture and storage (CCS) is more complex.

### Now let's take a look at the ocean:

For the last half-century around 90% of excess heat energy has entered the ocean, and about 30% of emitted CO<sub>2</sub>. It is no surprise that these have changed ocean chemistry and its physical properties. Heat energy is stored beneath thermoclines, but can re-emerge as the strata shift or overturn.

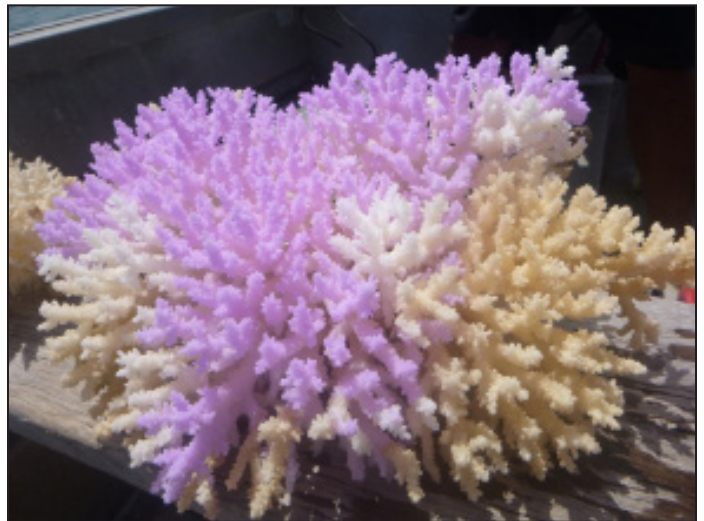
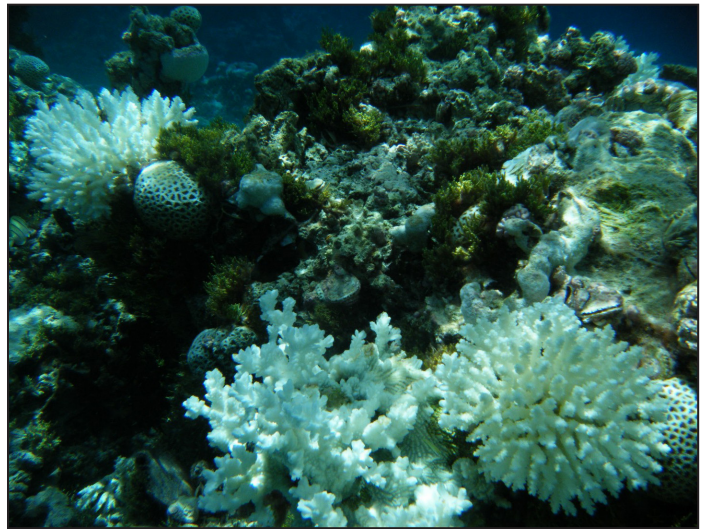
*El Niño* Southern Oscillation (ENSO) is a phenomenon driven by atmospheric and oceanographic conditions in the Pacific Ocean. It raises sea temperature, changes current flows, trade-winds and rainfall patterns. Unfortunately it impacts global events, including increased wildfires in Indonesia and Australia. Its *La Niña* phase tends to be cooler. In 2019 we are in a neutral phase with *El Niño* soon. Strong *El Niños* were unknown in nature before 1982.

### Corals

Corals are colonial animals that have tiny *zooxanthellae* living inside their dermal tissue; these symbionts photosynthesise carbon to produce sugars for the coral host. When sea temperatures rise, *zooxanthellae* food production increases until it becomes toxic (free radicals), so corals eject them leaving the *bleached* carbonate structure. Coral polyps might still be alive at this point, but rely on filter-feeding; however, there may be insufficient dermal cells left to provide proper nutrition.

### Tongareva Atoll

The longest *El Niño* on record occurred between April 2015-



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**TOP:** Coral bleaching in January 2019 caused by u/v radiation as sea temperatures are normal. **CENTER:** Bleaching at depth during 2016 *El Niño* ~ water temperature was 38°C. **BOTTOM:** Stages of bleaching ~ brown is normal, lilac (and other vivid hues) indicates stress, white is bleached.

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May 2016. Tongareva Atoll (09° S; 158° W) suffered for five months. Lagoon temperature was 38° Celsius for weeks and nearshore ocean 34°C (White 2016). The entire 77 km of the outer reef bleached, as did every patch reef in the 233 km<sup>2</sup> lagoon. Worse still was 95% of giant clams (*Tridacna maxima*) died too: they also have zooxanthellae in the mantle. Clams are an important food resource for us: we control harvest using *rahui* (traditional ecosystem management). This terrible tragedy killed many thousands of shellfish. In 2018 a few clams appeared.

Because Tongareva had been near pristine the outer reef corals began to recover. January 2019: the author discovered bleaching again, but this time seawater was cooler. Increased u/v radiation is the likely cause. Greenhouse gases that contain bromines or chlorines degrade the stratospheric ozone layer and more sunlight enters. This bleaching event provided excellent research opportunities and we monitored the changes as they occurred; in 2016 bleaching had happened before we found it. A simple tool is the CoralWatch health card ([www.coralwatch.org](http://www.coralwatch.org)): *citizen science* from University of Queensland, Brisbane. We noticed corals showed vivid hues, a sign of sickness, before bleaching. Branching corals became more brittle and broke off, then plate corals too. In June 2019 the boulder corals began to recede and many disappeared! Interestingly, clams seemed unaffected.

Coral decalcification could be a consequence of increased ocean acidification. As CO<sub>2</sub> accumulates in the ocean, carbonic acid is formed (low pH). Carbonate ions needed for reef building become less available, also calcium carbonate structures start to dissolve (reefs and shells). A two-pronged attack on a vital ecosystem that sequesters huge volumes of carbon.

### Is anything else happening? Unfortunately, yes!

The *Inter-decadal Pacific Oscillation* (IPO) occurs over longer time-scales than ENSO: it also has a negative and positive phase. We are heading towards a simultaneous IPO+ and El Niño, but the background temperature is already warmer. Perhaps sea surface temperatures could reach 40°C. Increased tropical storms are likely.

Warmer oceans melt polar ice. Loss of sea ice, glaciers, and permafrost reduces *albedo* so that more irradiance is absorbed instead of being reflected (positive feedback loop). Sea level can rise from meltwater and thermal expansion.

Warmer seawater holds less oxygen, forcing mobile species to seek cooler, deeper water; sessile life will likely die. *Dead Zones* are either hypoxic or anoxic and becoming more common globally.

The sex of sea turtle embryos is determined by nest incubation temperature: females from warmer eggs, males from cooler ones. Research projects around the world are



© Photographs courtesy Dr Michael White

**TOP:** Top: Green sea turtle *Chelonia mydas* swimming underwater. **CENTER:** Dead turtle embryo around mid-term development. **BOTTOM:** Tallying success rate of a hatched turtle clutch, only 4 of 188 eggs didn't succeed.

starting to report feminisation of embryos due to a warming climate. Tongareva is the paramount sea turtle habitat in the central South Pacific (White 2014).

Increased u/v irradiance seems to be causing severe leaf

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loss in tree species, and pollen is becoming unviable. In turn foliage loss creates problems for nesting birds, as there is no shade.

Insects, especially bees, are disappearing in many places.

Alien invasive species are spreading rapidly, often because of global trade, indigenous species tend to be outcompeted. As habitats fail species have no place to go.

Plastics are a byproduct of the oil industry. The ocean is full of plastics. Corals in contact with plastics are much more susceptible to disease (Lamb et al 2018).

The most disturbing concern for scientists now is the rate of change: events and cascade effects are occurring so much faster than models predicted. Even if we stopped using fossil fuels today, we've already locked in changes that will continue for centuries. Ecosystems can reach 'tipping points' in which they flip into a completely new, irreversible, state.

### How do we fix our world?

During December 2015 almost every country in the world signed the Paris Agreement (United Nations Framework Convention on Climate Change); USA subsequently withdrew. The stated aim was to *limit global temperature rise to well below 2°C compared to the pre-industrial age.*

Another key convention is 'Agenda 2030: Transforming our world'. This consists of 17 Sustainable Development Goals (SDGs) and 169 targets. Signatories must do all SDGs, not cherry-pick a few easy ones. Goal 13 is climate action; Goal 14 life below water; Goal 15 life on land. Importantly, a response to one goal or target should not worsen another.

Sadly, USA has the greatest *per capita* Carbon Footprint: **17 tonnes CO<sub>2</sub>e per annum.** China is 8 tonnes CO<sub>2</sub>e per annum; India 4 tonnes CO<sub>2</sub>e per annum. It is true that China has the biggest overall emissions, but its population is 1.5 billion compared with USA's 326 million. All of America's wars are to do with oil (Iraq, Libya, Syria; Venezuela and now Iran). It is unsurprising that CO<sub>2</sub> emissions are rapidly increasing.

One further piece of legislation is the Majuro Declaration (2013) where a group of *highly ambitious* countries (many of them Pacific Island nations at great risk of being submerged by rising sea levels) determined to *limit global temperature rise to below 1.5°C.* We are already close to that limit.

All five previous mass-extinction events had GHGs as their proximate cause; most emissions were from volcanic activity and occurred over millions of years. The present (6<sup>th</sup>) extinction has humans as the driving force. The rate of increase of CO<sub>2</sub> levels is deeply disturbing. We might quibble over a small fluctuation (2 or 3 ppm) in the short



© Photographs courtesy Dr Michael White  
**TOP:** Much oceanic plastic is manufactured consumer goods. **CENTER:** Plastic bottles are everywhere. **BOTTOM:** Chairman Ru Taime and Dr Mike White sorting rubbish collected from lagoon ~ none is from our atoll.

term concentration, but looking back over one million years, the increase now is vertical. [we have data from rock strata, ice-cores, corals, tree rings etc].

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**LEFT:** Dr Mike White teaching university students at Linosa, Italy. **RIGHT:** Tagging blacktip reef shark *Carcharhinus melanopterus* at Tongareva 2018

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<https://www.stockholmresilience.org/>

In 2009 the Stockholm Resilience Centre produced the **Planetary Boundaries** concept as a *safe operating space for humanity*. It categorised the world into nine fundamental zones with increasing risk as each boundary margin is exceeded. Biodiversity has long been lost but gained hardly any political interest. Climate change is a much better motivator as it affects money and profit.

Let us be crystal clear: it is an overwhelming task to shift our world from a highly-polluting fossil fuel based economy, to one that runs on clean energy. Yet change we must. It is very likely we have missed the opportunity to mitigate the ravages of climate change, so now we must learn to adapt to the consequences of our inaction. We can call this the *procrastination principle*: each year of delay makes it harder to achieve the Paris Accord goals. The technology we need already exists; including to refreeze the polar regions (Sir David King, Climate Repair Institute).

For readers who find it hard to make up their minds about climate change, especially any man-made contribution, I suggest reading the IPCC reports. These are conservative, cautious, and explain their confidence levels. Science is based on facts:

<https://www.ipcc.ch>

<https://www.carbonbrief.org/state-of-the-climate-heat-across-earths-surface-and-oceans-mark-early-2019>

**Do we honestly believe that 250 years of Industrial Revolution have had no effect upon our planet?**

**It is for us to choose the sort of planet we want: a healthy, abundant, biodiverse and sustainable world, or a rapidly warming and failing biosphere.**

### REFERENCES

Crawford NC (2019) *Pentagon Fuel Use, Climate Change, and the Costs of War*. 38pp. Boston University.

Lamb JB, Willis BL, Fiorenza BA, Couch CS, Howard R, Rader DN, True JD, Kelly LA, Ahmed A, Jompa J, Harvell CD (2018) Plastic waste associated with disease on coral reefs. *Science* 359: 460-462.

SROCCC *Special Report on the Ocean and Cryosphere in a Changing Climate* (2019). IPCC

White M (2014) Tongareva Atoll: The most important sea turtle habitat in the Cook Islands. *Testudo* 8: 19-37. Permalink: <http://library.seaturtle.org/8489>

White M (2016) Too hot in Paradise! *The Marine Biologist*, April 2016: 26-27. Published by the Marine Biological Association <https://www.mba.ac.uk/marinebiologist/> Permalink: <http://library.seaturtle.org/9685>

White M (2019) *Initial Assessment of a New Coral Bleaching Event at Tongareva Atoll in the Northern Cook Islands*. Permalink: <http://library.seaturtle.org/11235>

*An interesting story on California:* <https://www.theguardian.com/commentisfree/2019/oct/29/has-the-climate-crisis-made-california-too-dangerous-to-live-in>

### ABOUT DR MICHAEL WHITE

a Marine Zoologist who has studied endangered sea turtles for over 25 years. He lives on Tongareva Atoll in remote Oceania where the people lead a subsistence way-of-life gathering resources directly from nature. Impacts of climate change are now a severe threat.

President of Hakono Hararanga Incorporated, Tongareva's Community Environmental Society. Works with local education, scientific research, collecting oceanic plastics from the uninhabited islets, tree-planting and forest-restoration (planted over 6000 trees in the last 18 months).

A Fellow of the Marine Biological Association of Great Britain. A Member of the IUCN Species Survival Commission: Marine Turtle Specialist Group. <https://hararanga.org>