Climate Change in northern Australia

Information on climate change for Aboriginal people living in the north

An Australian Government Initiative

CSIRO

Griffith UNIVERSITY

This booklet was produced by Griffith University and CSIRO Land and Water Flagship, as part of the Australian Government's Natural Resource Management Planning for Climate Change Fund.

Copyright and Disclaimer

Important Disclaimer

Further information

Dr Samantha Capon
Australian Rivers Institute - Griffith University
Phone: 0402 217 899
Email: s.capon@griffith.edu.au

Brendan Edgar
Phone: 0419 781 676
Email: brendan.edgar@gmail.com

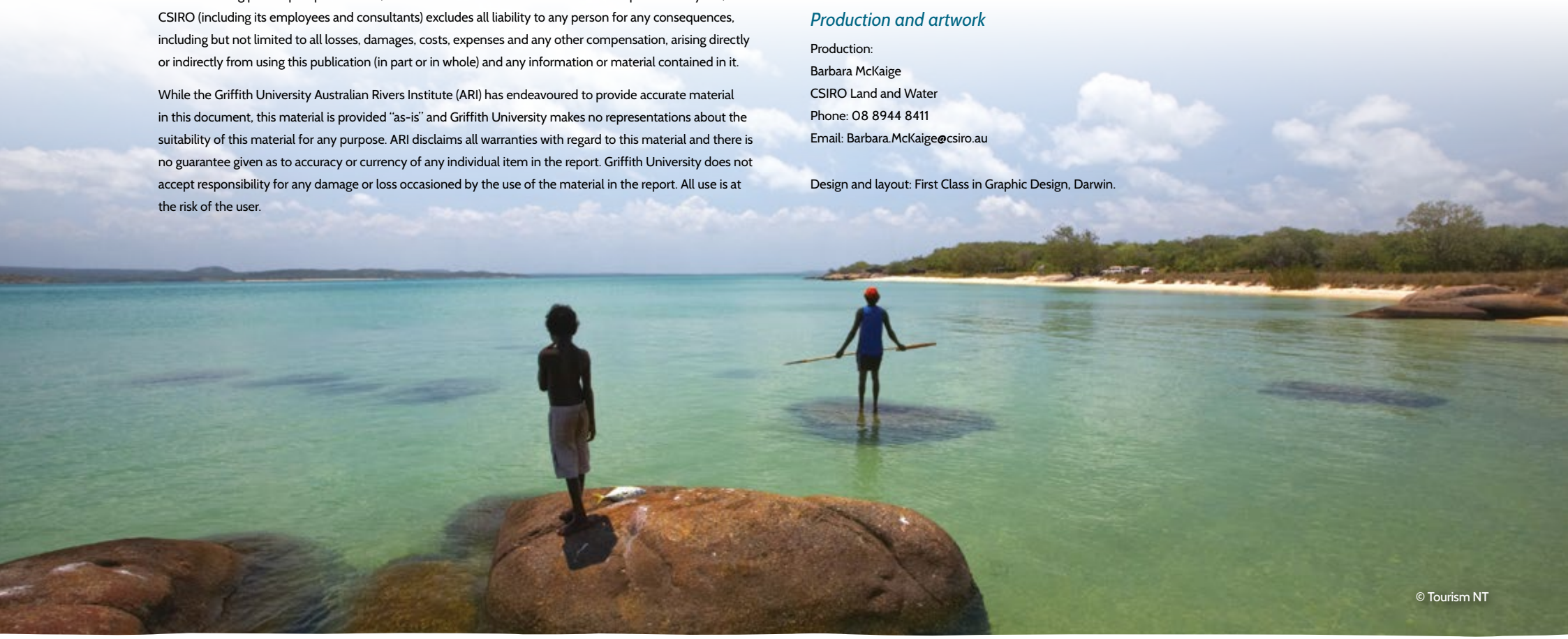
Cover images

Top End Sunrise © Keith McGuinness

Production and artwork

Production:
Barbara McKaige
CSIRO Land and Water
Phone: 08 8944 8411
Email: Barbara.McKaige@csiro.au

Design and layout: First Class in Graphic Design, Darwin.



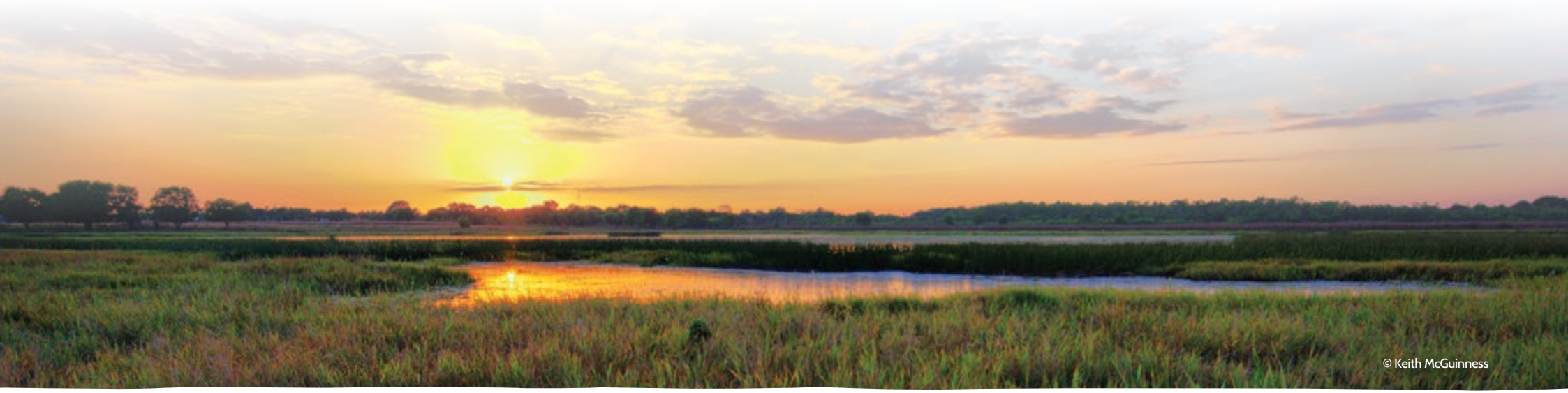
© Tourism NT

Introduction

The Earth's climate is changing, and human activities have contributed to this. There will be significant environmental, economic and social impacts of climate change over the coming decades and long into the future.

This is an information booklet about climate change and its potential impacts for Aboriginal people living in northern Australia. It is based on knowledge collected by scientists from CSIRO and the Australian Government's Bureau of Meteorology.

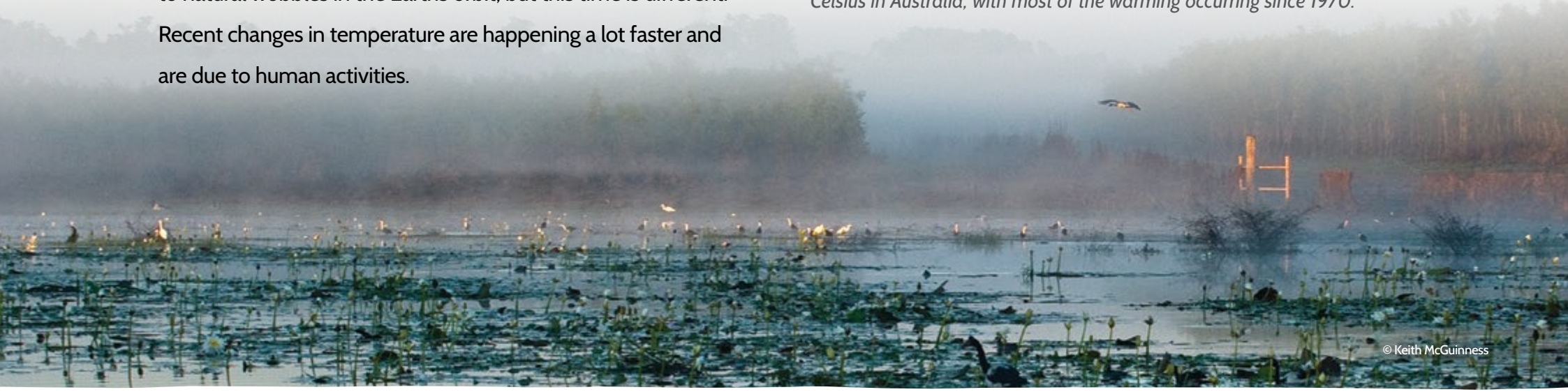

© Peter Christophersen

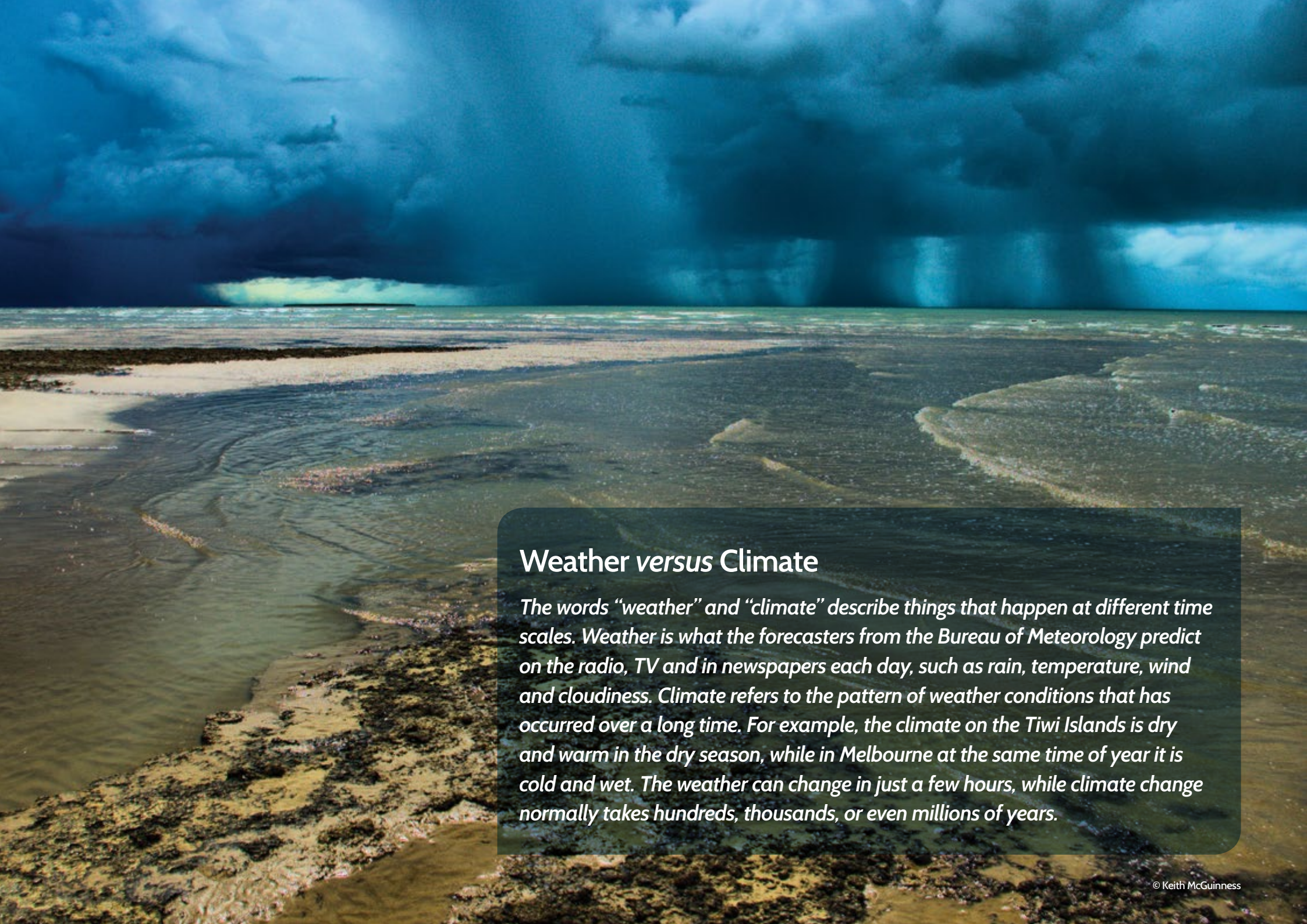

© Keith McGuinness

Our climate is changing!

The Earth is getting warmer. Over the past 100 years the average daily temperature in Australia has risen by nearly 1° Celsius, and seven of the ten warmest years on record have occurred since 1998. It is very likely that most of the warming since the mid-20th century is due to increases in heat-trapping greenhouse gases in the atmosphere due to human activities, mainly by burning fossil fuels such as oil, gas and coal. Warmer temperatures are causing other changes around the world, such as rising sea levels, changes in rainfall patterns, and more-extreme weather events. The Earth's climate has changed before, such as during ice ages due to natural wobbles in the Earth's orbit, but this time is different. Recent changes in temperature are happening a lot faster and are due to human activities.

Since 1910 average daily temperatures have increased by nearly 1˚ Celsius in Australia, with most of the warming occurring since 1970.



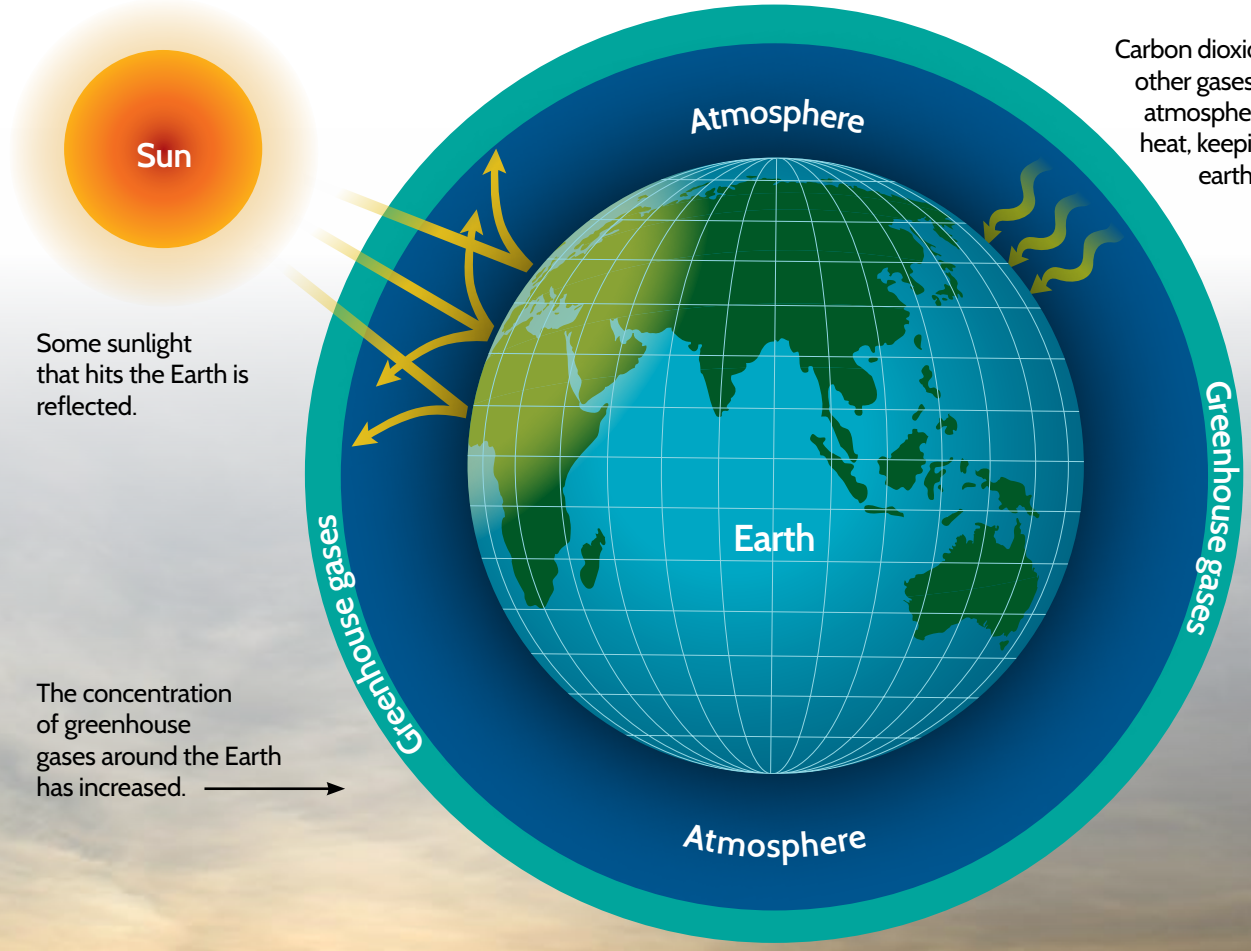


Weather *versus* Climate

The words "weather" and "climate" describe things that happen at different time scales. Weather is what the forecasters from the Bureau of Meteorology predict on the radio, TV and in newspapers each day, such as rain, temperature, wind and cloudiness. Climate refers to the pattern of weather conditions that has occurred over a long time. For example, the climate on the Tiwi Islands is dry and warm in the dry season, while in Melbourne at the same time of year it is cold and wet. The weather can change in just a few hours, while climate change normally takes hundreds, thousands, or even millions of years.

What is the greenhouse effect?

The greenhouse effect is a natural process where particular gases in the air hold heat in from the Sun. It keeps the Earth at a good temperature to support life. Without this trapped heat, the Earth would be 33°C cooler and life as we know it would not be possible. The main gas that makes up the greenhouse effect is water vapour, but carbon dioxide, methane and nitrous oxide are also important. These are called greenhouse gases.



People's activities over the past two hundred years have put much more greenhouse gas into the air. This is mostly from burning of fossil fuels like oil, petrol and diesel that contain carbon, and have been lying underground for millions of years. The concentration of carbon dioxide in the atmosphere has risen by more than 40 per cent since people started burning fossil fuels and the Earth's climate is starting to get warmer. This is called global warming.

Most scientists believe that global warming is changing our climate. It is changing the rainfall patterns and making more storms and more very hot days. Higher temperatures cause water to expand and ice sheets to melt, and so sea levels are rising. Scientists aren't sure exactly what the climate will be like in future, and how it will affect things. However, they expect that it will change where different plants and animals occur, and will have a range of effects on people.

Carbon dioxide (CO_2) is an important greenhouse gas influenced by human activities. The level of CO_2 has risen from about 280 parts per million (ppm) in 1800 to 395 ppm in 2013, and is currently increasing by more than 2 ppm each year. CO_2 levels are rising mainly because of the burning of fossil fuels.

Water Vapor: It's a Gas!

Water can take the form of an invisible gas called water vapor. Water vapor is naturally present in the atmosphere and has a strong effect on weather and climate. As the planet gets warmer, more water evaporates from the Earth's surface and becomes vapor in the atmosphere. Water vapor is a greenhouse gas, so more water vapor in the atmosphere leads to even more warming.

How does carbon get in living things? Plants take in CO_2. They keep the carbon and give away the oxygen. Animals breathe in the oxygen and breathe out carbon dioxide.

Carbon

All living things on Earth contain carbon. Lots of it! If you weigh 100 kilograms, 18 kilograms of you is pure carbon. Plants are almost half carbon. In its pure form carbon is black and sooty but when it combines with other elements it forms new materials. For example, when carbon (C) and oxygen (O) combine they form an invisible, odourless gas called carbon dioxide, or CO2, which is a heat-trapping Greenhouse gas. Whenever we burn fossil fuels such as diesel, petrol, and natural gas–whether it's to drive our cars, use electricity, cook on our gas stoves–we are producing carbon dioxide.

The atmosphere isn't the only part of the Earth that has carbon. The oceans store large amounts of carbon, and so do plants, soil, and deposits of coal, oil, and natural gas deep underground. Carbon naturally moves from one part of the Earth to another through the carbon cycle. But right now, by burning fossil fuels, people are adding carbon to the atmosphere (in the form of carbon dioxide) faster than natural processes can remove it. That's why the amount of carbon dioxide in the atmosphere is increasing, which is causing global climate change.

In Australia, the number of days with record hot temperatures has increased each decade over the past 50 years.

The climate is changing now!

The rise in average temperature is only one way we can tell that the climate is changing. The observations and measurements made by scientists from all over the world show that the climate has already started to change.

What are the signs of climate change?

Higher temperatures

- Over the past 100 years the average daily temperature in Australia has risen by nearly 1°C.
- Sea-surface temperatures have also increased by almost 1°C since 1910. In 2010 sea-surface temperatures in the Australian region were the highest on record.

Melting sea-ice and glaciers

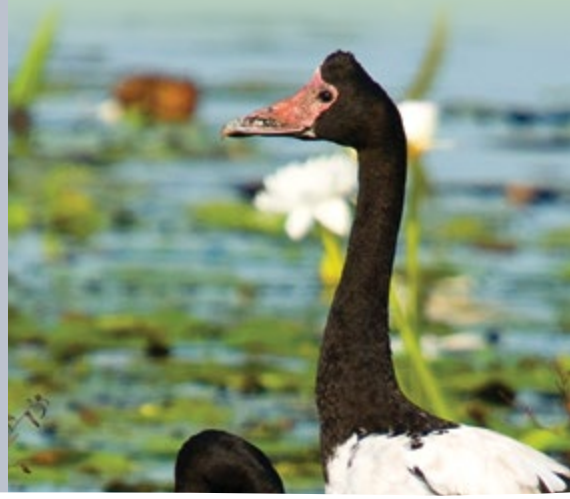
- The area of Arctic sea-ice is much smaller than it was in the 1970s, with a 40 per cent decrease in its average thickness. Glaciers are rivers of ice that occur in the coldest parts of the world; they have been melting over the last 50 years, and the rate of melting is speeding up. Many glaciers have shrunk dramatically.

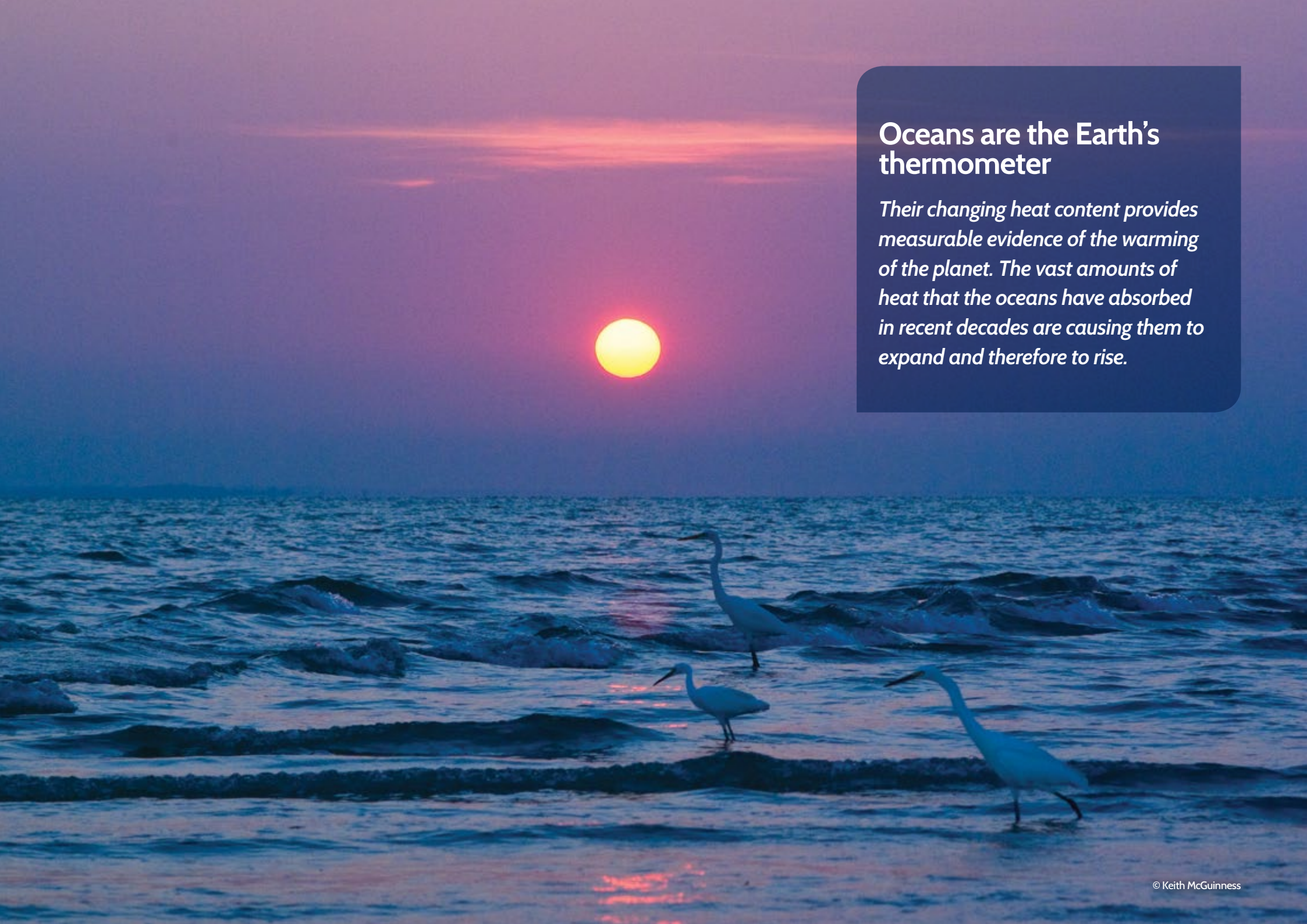
Rising sea levels

- Higher temperatures cause water to expand, and so sea levels are rising. Water from melting glaciers and land-based ice sheets also causes sea levels to rise. Over the past 20 years sea-levels in northern Australia have been rising by about 10mm each year. This is much greater than the sea-level rise in southern Australia, and is two to three times greater than the global average.

Changes in plants and animals

- Many plants and animals have recently shifted where they live as the climate is changing. Scientists are concerned that some species will have nowhere to live if the climate changes too much.



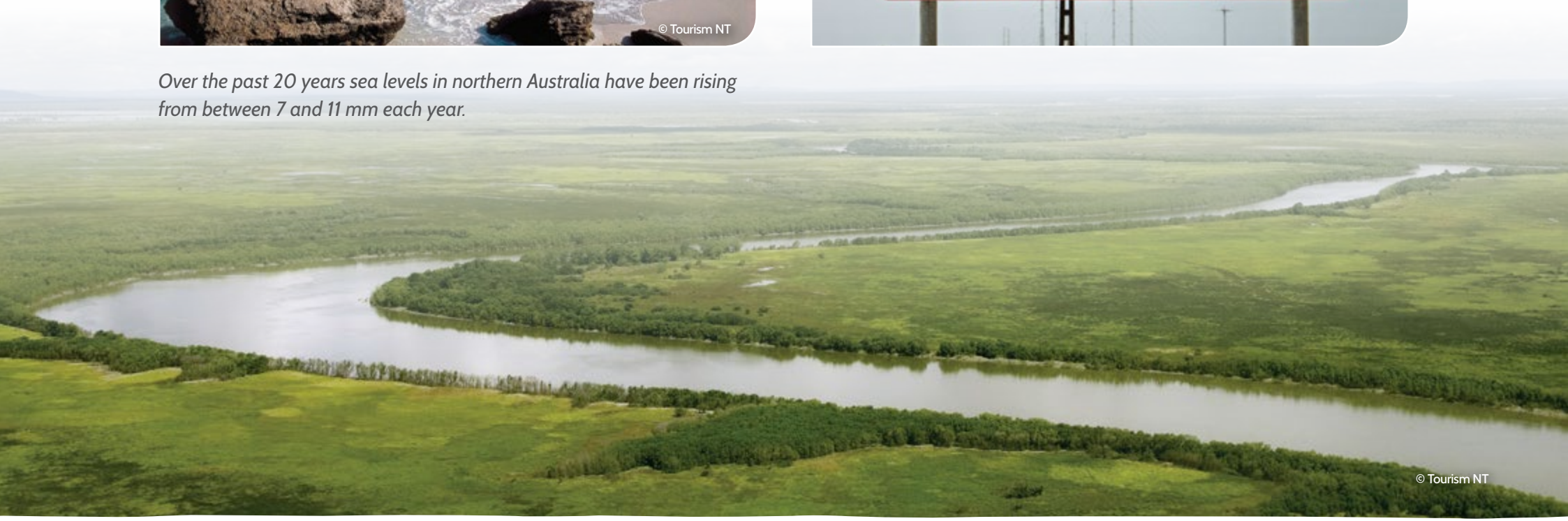


Oceans are the Earth's thermometer

Their changing heat content provides measurable evidence of the warming of the planet. The vast amounts of heat that the oceans have absorbed in recent decades are causing them to expand and therefore to rise.

What's happening in northern Australia?

Over the past 20 years sea levels in northern Australia have been rising from between 7 and 11 mm each year.



Parts of the Gulf of Carpentaria coastline are very low lying. Sea-level rise would result in damage to communities, and loss of habitat for coastal plants and animals.

Fire produces the most greenhouse gas emissions in northern Australia

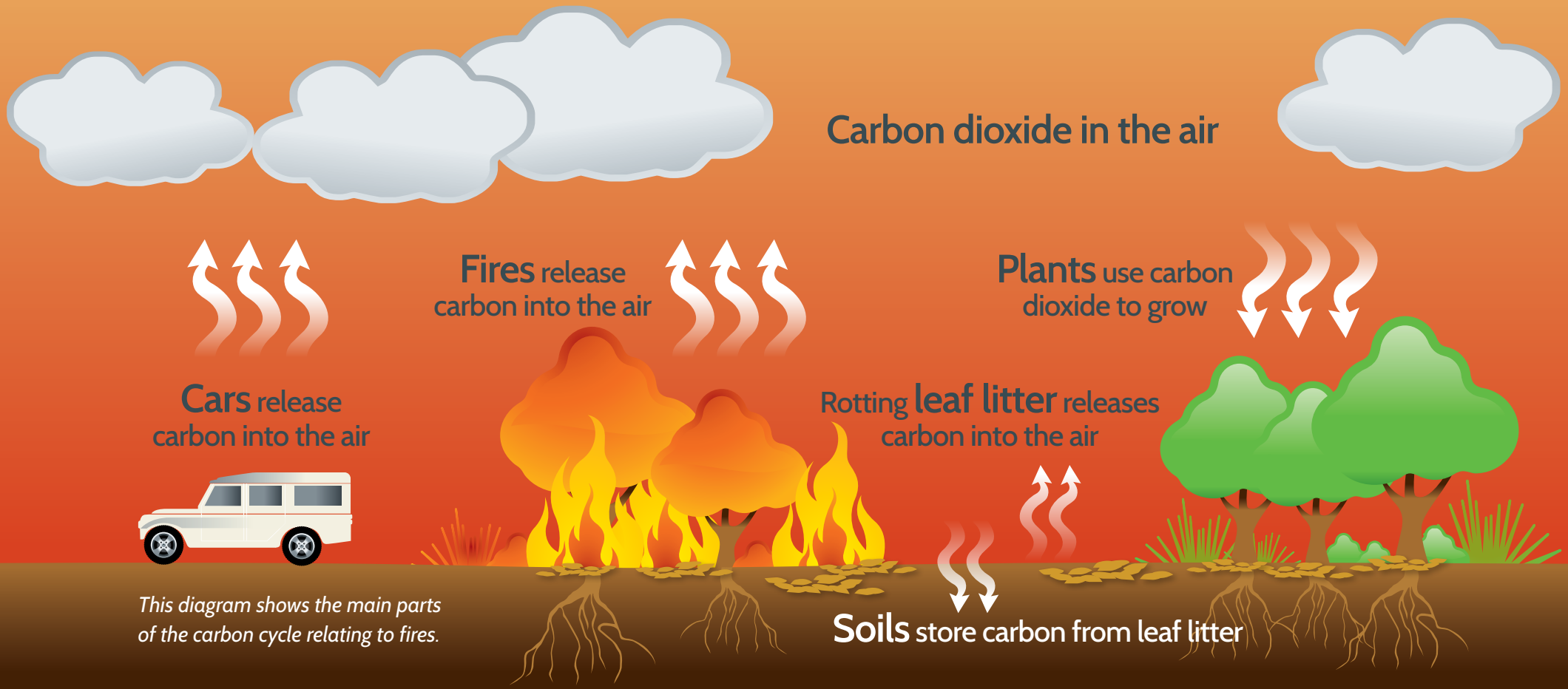
In northern Australia the biggest single contributor to Australia's Greenhouse gas emissions is bushfires. Up to a third of northern Australia is burnt every year.

Fire changes the amount of Greenhouse gas in the atmosphere in two ways. First, burning gives off the important Greenhouse gases methane and nitrous oxide. Fires produce nearly a half of the Northern Territory's emissions of methane and nitrous oxide. Similar proportions of Greenhouse gases are produced in northern Queensland and the Kimberley region of Western Australia.

Second, burning can change the amount of carbon stored in vegetation and in the soil. Plants take carbon from the air

through a process called photosynthesis. A lot of this carbon makes the wood in trees. Some of it ends up on the ground as organic matter in the soil. The carbon is released back into the air when trees die and rot away. Scientists aren't sure exactly how all this is affected by different ways of burning, but it is very likely that with less fire there will be more carbon stored in vegetation and soil.

The Carbon Cycle



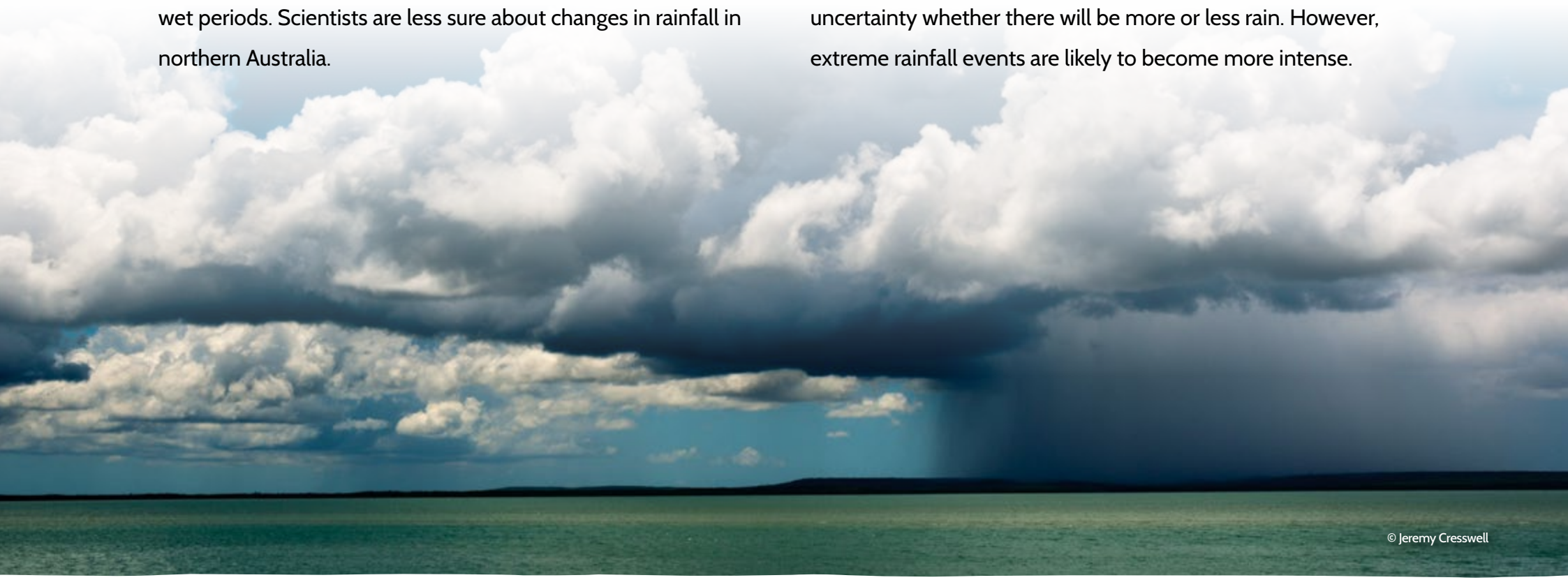
This diagram shows the main parts of the carbon cycle relating to fires.

Expected changes in the climate

The Top End of the Northern Territory

Average temperatures in the Top End are expected to increase by around 1.2°C by 2030 and by around 2.0°C by 2090 under the intermediate emissions scenario. An increase in the number of droughts is expected in southern Australia, but it is also likely that rainfall will be heavier in many places during wet periods. Scientists are less sure about changes in rainfall in northern Australia.

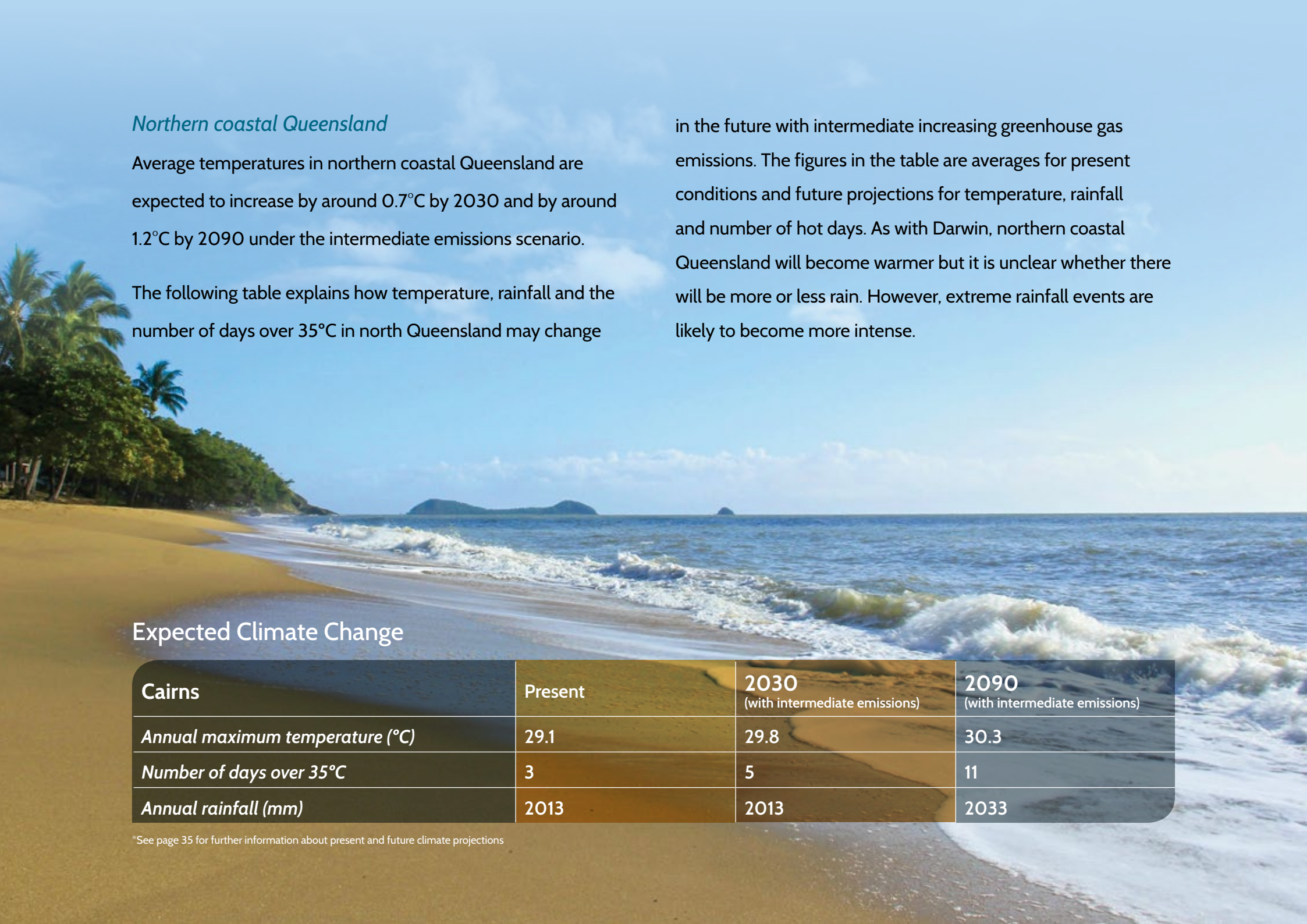
The table on the next page explains how temperature, rainfall and the number of days over 35°C in Darwin may change in the future with intermediate increasing greenhouse gas emissions. The figures in the table are averages for present conditions and future projections for temperature, rainfall and number of hot days. While it is clear that it will become warmer, there is uncertainty whether there will be more or less rain. However, extreme rainfall events are likely to become more intense.



Expected Climate Change

Darwin	Present	2030 (with intermediate emissions)	2090 (with intermediate emissions)
Annual maximum temperature (°C)	32.1	33.3	34.1
Number of days over 35°C	11	43	111
Annual rainfall (mm)	1586	1602	1586

*See page 35 for further information about present and future climate projections



Northern coastal Queensland

Average temperatures in northern coastal Queensland are expected to increase by around 0.7°C by 2030 and by around 1.2°C by 2090 under the intermediate emissions scenario.

The following table explains how temperature, rainfall and the number of days over 35°C in north Queensland may change in the future with intermediate increasing greenhouse gas emissions. The figures in the table are averages for present conditions and future projections for temperature, rainfall and number of hot days. As with Darwin, northern coastal Queensland will become warmer but it is unclear whether there will be more or less rain. However, extreme rainfall events are likely to become more intense.

Expected Climate Change

Cairns	Present	2030 (with intermediate emissions)	2090 (with intermediate emissions)
Annual maximum temperature (°C)	29.1	29.8	30.3
Number of days over 35°C	3	5	11
Annual rainfall (mm)	2013	2013	2033

*See page 35 for further information about present and future climate projections

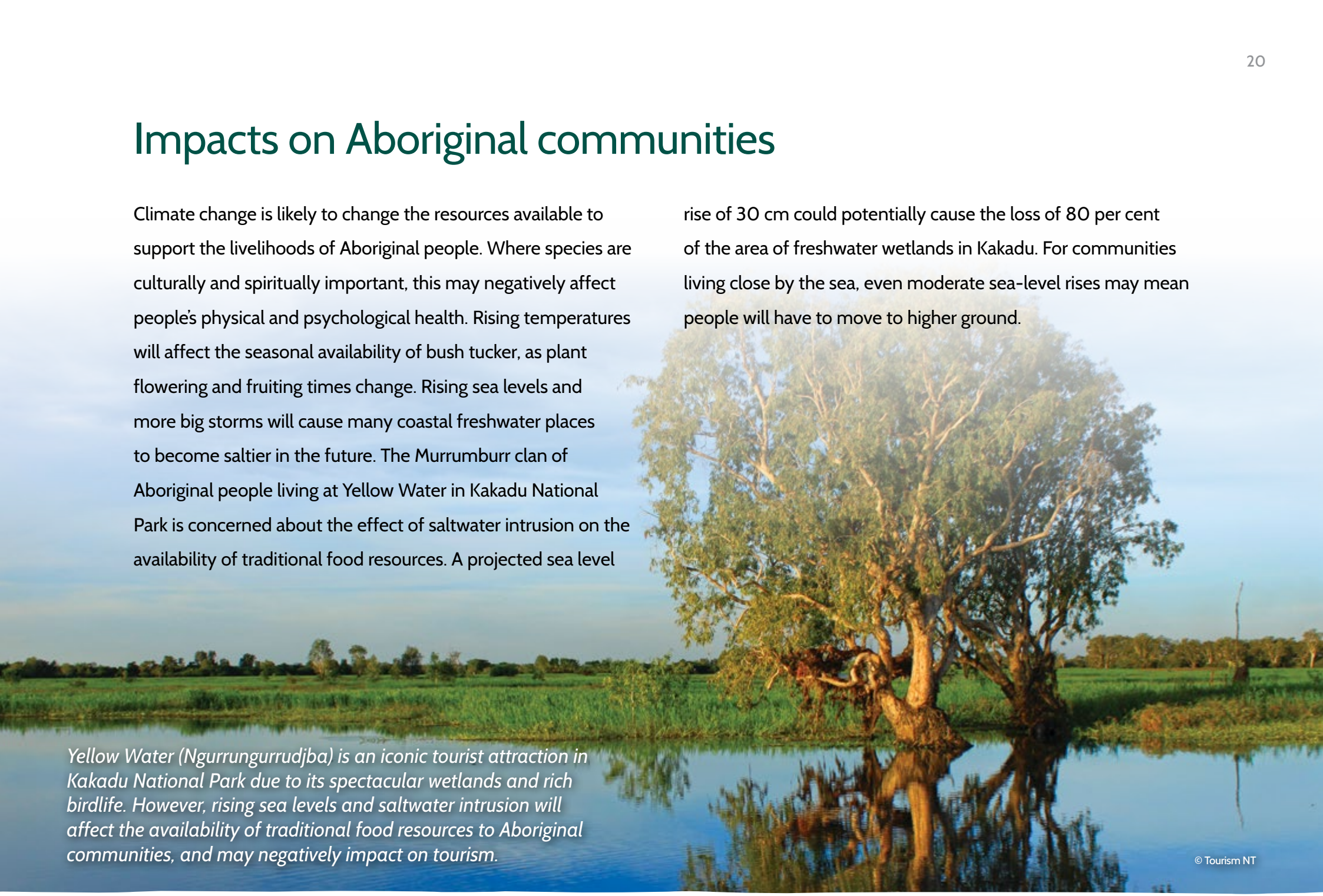
Potential impacts

Some examples of potential impacts in the Top End and north Queensland from climate change are:

- Increased exposure of remote communities to heat stress, diseases, extreme rainfall events and flooding.
- Flooding of freshwater wetlands with salty water, due to rising sea levels.
- Fewer tropical cyclones overall, but an increase in the proportion of more powerful (category 3 or higher) cyclones. More powerful cyclones will cause more damage to the environment, especially to coastal and marine areas.
- A significant loss of biodiversity in the Great Barrier Reef and Queensland Wet Tropics by 2020.
- The risk of inundation by a 1-in-100 year storm surge in Cairns area may more than double by 2050.

Impacts on Aboriginal communities

Climate change is likely to change the resources available to support the livelihoods of Aboriginal people. Where species are culturally and spiritually important, this may negatively affect people's physical and psychological health. Rising temperatures will affect the seasonal availability of bush tucker, as plant flowering and fruiting times change. Rising sea levels and more big storms will cause many coastal freshwater places to become saltier in the future. The Murrumburr clan of Aboriginal people living at Yellow Water in Kakadu National Park is concerned about the effect of saltwater intrusion on the availability of traditional food resources. A projected sea level rise of 30 cm could potentially cause the loss of 80 per cent of the area of freshwater wetlands in Kakadu. For communities living close by the sea, even moderate sea-level rises may mean people will have to move to higher ground.



Yellow Water (Ngurrungurrudjba) is an iconic tourist attraction in Kakadu National Park due to its spectacular wetlands and rich birdlife. However, rising sea levels and saltwater intrusion will affect the availability of traditional food resources to Aboriginal communities, and may negatively impact on tourism.

The warmer air and ocean surface temperatures brought on by climate change can result in coral reefs losing their beautiful colours, a process known as bleaching. Many of the bleached reefs do not recover from such events. The many fish and other marine animals that depend on coral reefs for food and shelter may become more difficult to find, and traditional owners may have to travel further distances or spend more time on hunting and fishing to get bush tucker like turtle. The seasons when bush tucker becomes available may also change, sometimes coming early and sometimes late. Important plants and animals, totems and sacred sites might be vulnerable to the impacts of climate change. If some bush foods become more difficult to find, fisheries are damaged, and important habitats are lost, people may have to rely more on food from shops and their diets may suffer. Moving people away from country that is prone to flooding may result in a loss of connection to culture and place.

With global warming a greater proportion of cyclones of category 3 and above will cause more damage to the environment, especially to coastal and marine areas. In the Gulf of Carpentaria region cyclones in the 1980s resulted in widespread damage to coastal vegetation and seagrass beds. Large storm surges killed many marine animals.

Remote communities are particularly vulnerable to the impacts of climate change because of limited access to health, education and other services. Increasing temperatures may result in more cases of heat stress and dehydration. A hotter climate is likely to increase the spread of viruses and germs.

An increase in the proportion of high-intensity cyclones will have a significant impact on the infrastructure of remote communities. In 2006, in Maningrida in Arnhem Land, Cyclone Monica – a category 5 cyclone – caused destructive winds, storm surges and heavy rains that resulted in flooding along the rivers and damage to infrastructure. The roof of the school was torn off, roads were blocked by fallen trees and powerlines across the township were down. About 7000 km^2 of country (about one third the size of Kakadu National Park) was severely damaged by the cyclone and the recovery of the vegetation has been slow. Kakadu experienced the highest rainfall event in living memory as Cyclone Monica stayed over Jabiru dumping more than 300 mm of rain on the town. Many people had to be evacuated and access to the Park was cut as the highways were flooded for over a week.

During Cylone Monica in 2006, 75 per cent of houses in Maningrida suffered damage from strong winds or fallen tree branches.

In Arnhem Land, more than 7000 km² of mangroves, Melaleuca swamps and savanna woodlands were damaged by Cyclone Monica in 2006.

Roads, railways and airstrips between large regional centres, such as Darwin, and remote Aboriginal communities are likely to be damaged or cut off for longer periods by big storms and flooding. This could affect the provision of goods and services in the future, and may cause food prices to rise. Flooding may also cut access to schools. Telephone lines and communication networks are also likely to be affected by more extreme weather events, and will be costly to fix because of their remote location. Bigger storms and more intense cyclones may also threaten water quality and the maintenance of sewerage systems.

Aboriginal communities rely heavily on natural resources for customary use and business. Increased flooding and hotter, drier periods in the future could cause problems for Aboriginal nature-based businesses, such as cultural tours and recreational fishing and hunting, if fewer visitors are willing to travel to remote regions. Community enterprises, such as bush tucker products, will most likely have to pay increased transport costs to get their goods to markets, and may suffer more disruptions to business because of extreme weather events.

However, there are also some opportunities arising from the need for better management of ecosystems impacted by climate change. Examples of new industries and economic opportunities include carbon farming and greenhouse gas abatement and payment for environmental services, such as weed and feral animal management.

The Sir Edward Pellew Islands in the Gulf of Carpentaria are home to important sea turtle nesting beaches. Rising temperatures will affect the ratio of male and female sea turtles born on the beaches and will have a long-term impact on the health of turtle populations.

What can be done?

There are two approaches that people can take to manage climate change: **Mitigation** and **Adaptation**.

Mitigation involves reducing greenhouse gas emissions in order to limit climate change. To have a big effect this requires action at the global level with cooperation between all countries.

Adaptation involves changes we can make to help us cope with climate change. Adaptation to changes in climate is nothing new. Throughout history, Aboriginal people have adapted to different climates and environmental changes. However, the current rate of global climate change is unusually high compared to past changes that people have experienced.

Reducing the number of fires that burn late in the dry season will help to lower greenhouse gas emissions. This is called greenhouse gas abatement.

Climate change mitigation

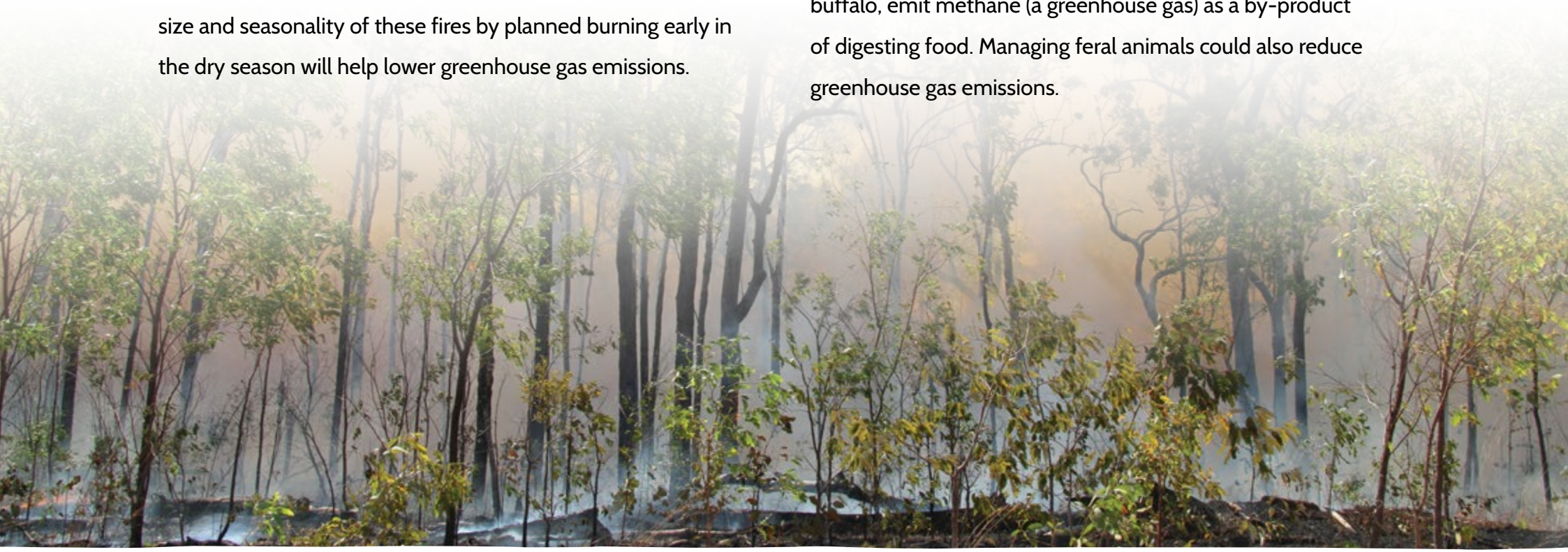
Reducing greenhouse gas emissions

In northern Australia the biggest single contributor to Australia's greenhouse gas emissions is bushfires. Top End fires produce up to 50 per cent of the Northern Territory's greenhouse gas (methane and nitrous oxide) emissions. Similar proportions of greenhouse gases are produced by fires in northern Queensland and the Kimberley region of Western Australia. Reducing the size and seasonality of these fires by planned burning early in the dry season will help lower greenhouse gas emissions.

Storing more carbon in the landscape

Carbon sequestration describes the long-term storage of carbon in plants and the soil. Planting more trees and reducing fires can help increase the amount of carbon stored in the landscape.

Farm animals, such as cattle, and feral animals, such as water buffalo, emit methane (a greenhouse gas) as a by-product of digesting food. Managing feral animals could also reduce greenhouse gas emissions.



Making the right energy choices

There is a range of energy options that don't require the burning of fossil fuels, and therefore don't produce Greenhouse gases. Renewable energy sources like solar, wind and hydro-power are likely to be more widely used than they are at present. Nuclear energy may become an economic option for power generation in Australia but high costs and the long time needed to develop nuclear power plants, along with poor public support, currently make this difficult to put into practice. The development of electric and hybrid cars is a step towards more environmentally-friendly transport.

There are also small, low cost changes that everyone can make to help save energy. Some examples are:

- Energy-efficient building design, including shading and solar power
- Using ceiling fans instead of air-conditioners;
- If air-conditioners are on, keep doors, windows and louvres closed;
- Turning off electrical goods, like kettles or televisions, at the wall socket when not in use;
- Using low energy light bulbs;
- Growing fruit and vegetable in home gardens;
- Recycling paper, glass and plastic;
- Walking or cycling more;
- Sharing car and 4WD travel to reduce the number of vehicles on the road.

Reducing greenhouse gas emissions from fire

Greenhouse gases are released by the big wildfires that sweep through remote areas of northern Australia during the end of the dry season. Reducing the size of these fires by burning more country early in the dry season will help to lower the amount of greenhouse gases in the atmosphere. This is called greenhouse gas abatement and it is already being practised by some Aboriginal ranger groups. For example, the Western Arnhem Land Fire Abatement (WALFA) project manages country for greenhouse gas abatement. The project started in 2004 with $17 million funding from the energy company, Conoco-Phillips. Aboriginal traditional owners and ranger groups are employed to burn early in the dry season to limit the number of unmanaged wildfires later in the year. This reduces overall greenhouse gas emissions and also helps protect the plants and animals of Arnhem Land and Kakadu National Park.

A number of similar projects are now occurring across northern Australia under the guidance of the North Australian Indigenous Land and Sea Management Alliance (NAILSMA), as well as by organisations such as the Tiwi Land Council.

The Tiwi Carbon Study is a research partnership between the Tiwi Land Council, Tiwi Plantations and CSIRO. It aims to identify the potential of fire management for greenhouse gas abatement on the Tiwi Islands, as a basis for possible livelihood opportunities for Tiwi people.

Climate change adaptation

Coping with sea-level rise and coastal flooding

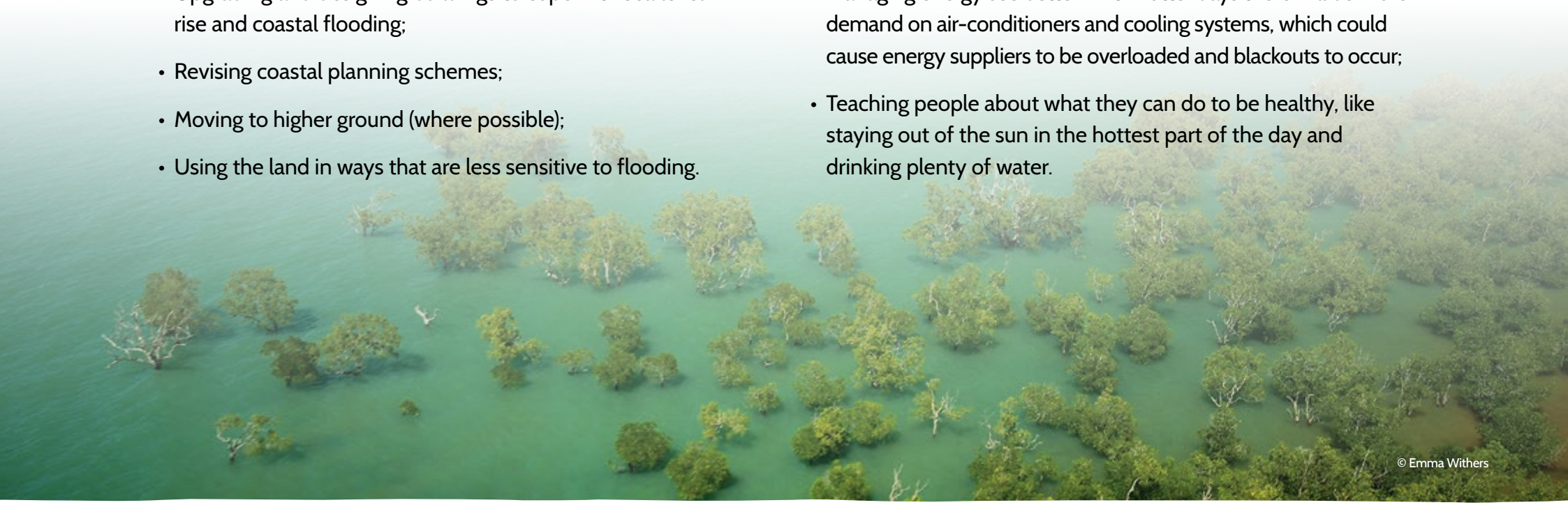
Lowering the risks from sea-level rise and coastal flooding calls for government, industry, communities and individuals to work together to come up with practical solutions, such as:

- Early warning systems and well-understood evacuation processes;
- Building beach defences, such as wave breaks to reduce flood risk;
- Upgrading and designing buildings to cope with sea level rise and coastal flooding;
- Revising coastal planning schemes;
- Moving to higher ground (where possible);
- Using the land in ways that are less sensitive to flooding.

Coping with higher temperatures

A greater number of hot days are expected in the future, which may cause more problems for people's health. Things that can be done to prepare for hotter weather include:

- Upgrading and designing buildings to cope with more-extreme conditions;
- Ensuring good communication and coordination across the health care system;
- Managing energy use better. With hotter days there will be more demand on air-conditioners and cooling systems, which could cause energy suppliers to be overloaded and blackouts to occur;
- Teaching people about what they can do to be healthy, like staying out of the sun in the hottest part of the day and drinking plenty of water.



Research and monitoring

Researchers are keen to continue to work with Aboriginal communities to better understand climate change, and to address the questions important to Aboriginal people about climate change impacts and adaptation options. Learning about how people have coped with changes in the past can help shape management plans and strategies for the future. We all have a role to play in teaching our families and communities about climate change, and what we can do to help manage impacts. Long-term monitoring, for example, is an important way to learn about how the climate is changing, and what effects those changes might have on our lives and environment.

Gooniyandi people from the Fitzroy River region in the Kimberley documenting information about seasons and weather patterns with CSIRO's Emma Woodward, as part of a Tropical Rivers and Coastal Knowledge project.

© Tourism NT

Glossary of Climate Change terms

Abatement: reduction in greenhouse gas emissions.

Adaptation: ways of coping with the impacts of global warming on species, ecosystems and people.

Anthropogenic: caused by human activities.

Biodiversity: life in all its forms, essential to maintaining functioning ecosystems that provide services essential for human survival and quality of life.

Carbon credit: used in emissions trading schemes (see emissions trading), where one credit gives the owner the right to emit one tonne of CO_2.

Carbon cycle: the movement of carbon through the atmosphere, oceans and water, living things, soils and geological deposits.

Carbon dioxide (CO_2): the most common greenhouse gas (other major greenhouse gases include methane and nitrous oxide); it is released by burning the bush and fossil fuels, land clearing and cropping.

Carbon neutral: no overall effect on greenhouse gas emissions.

Carbon offsetting: investing in a project that will lead to Greenhouse gas abatement (for example, planting trees or building renewable energy power stations to avoid the construction of coal ones).

Carbon price: puts a price on greenhouse gas emissions to create a disincentive for their release (and incentive to capture or avoid them). A carbon price can be imposed through a carbon tax, an emissions trading scheme (which fixes the emission level and allows price to vary) or a variety of other mechanisms.

Carbon sequestration: the uptake and storage of carbon, for example, by trees.

Carbon sink: entities like trees, soils and oceans that store more carbon than they release.

Climate change: significant changes from one climatic condition to another, commonly referring to the increase in Earth's surface temperature caused by human activities. Also, often called global warming, anthropogenic climate change, anthropogenic global warming, and the enhanced greenhouse effect.

Emissions trading: a market-based scheme that allows companies to either reduce emissions or pay for the right to pollute (with the money paid being used to reduce emissions elsewhere).

Fossil fuel: fuel of biological (plant and animal) origin that has become fossilised over millions of years, and is largely comprised of carbon and hydrogen. Examples include, coal, natural gas and oil.

Global warming: see climate change.

Greenhouse gases: gases such as carbon dioxide, water vapour, methane, nitrous oxide, ozone, and various fluorocarbons.

Greenhouse effect: the effect created by the band of greenhouse gases that blanket the Earth. The greenhouse effect keeps the Earth's surface within a temperature range that makes life on Earth possible.

Mitigation: actions to reduce or avoid greenhouse gas emissions, in order to avoid global warming.

Renewable energy: energy derived from the wind, sun, tides and other sources that, for all practical purposes, cannot be depleted.

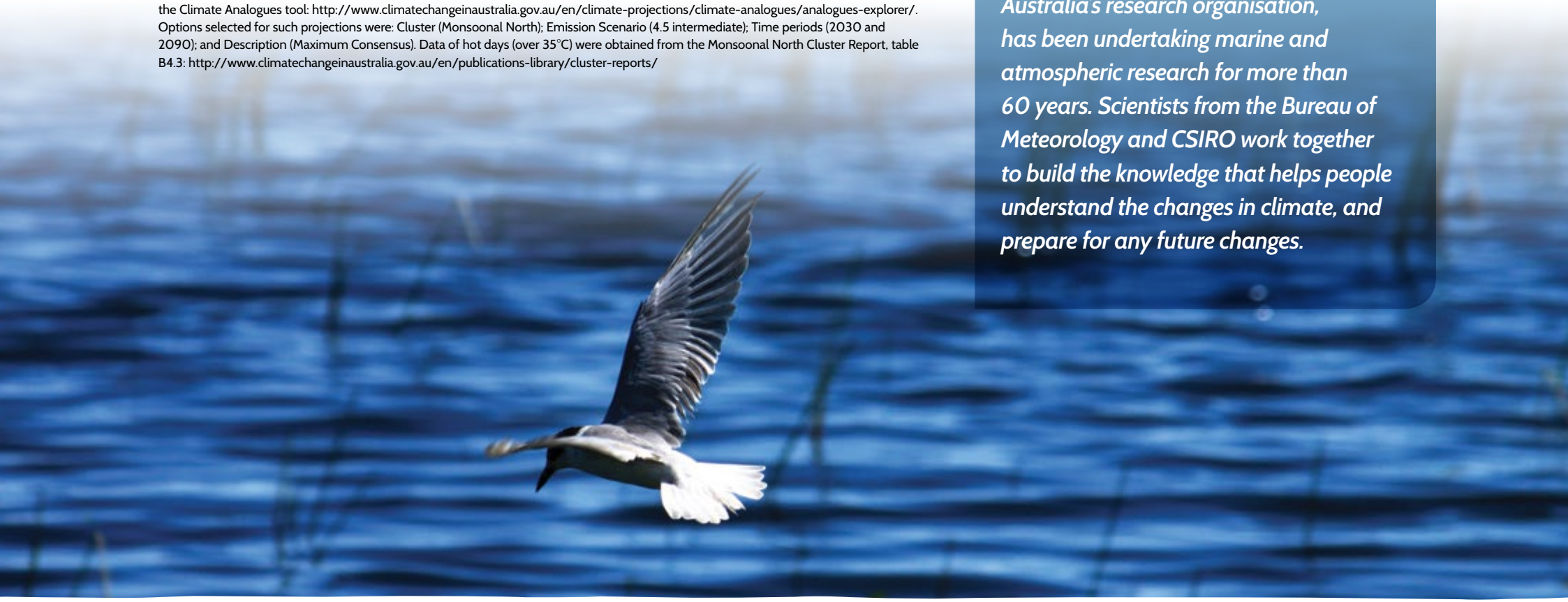
References

Climate change: science and solutions for Australia, (2011) Edited by **Helen Cleugh**, **Mark Stafford Smith**, **Michael Battaglia** and **Paul Graham**. CSIRO

CSIRO and Bureau of Meteorology (2014). *State of the Climate 2014* www.csiro.au/State-of-the-Climate-2014

Green D, **S Jackson** and **J Morrison** (2009) *Risks from Climate Change to Indigenous Communities in the Tropical North of Australia.* Department of Climate Change and Energy Efficiency: Canberra

*Climate information tables on pages 17 & 18: Data of present and future climate projections (temperature and rainfall) were obtained using the Climate Analogues tool: http://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-analogues/analogues-explorer/. Options selected for such projections were: Cluster (Monsoonal North); Emission Scenario (4.5 intermediate); Time periods (2030 and 2090); and Description (Maximum Consensus). Data of hot days (over 35°C) were obtained from the Monsoonal North Cluster Report, table B4.3: http://www.climatechangeinaustralia.gov.au/en/publications-library/cluster-reports/



Where does information about the climate come from?

The Australian Government's Bureau of Meteorology has been observing, reporting and researching Australia's weather since 1908 while CSIRO, Australia's research organisation, has been undertaking marine and atmospheric research for more than 60 years. Scientists from the Bureau of Meteorology and CSIRO work together to build the knowledge that helps people understand the changes in climate, and prepare for any future changes.

Further information

Dr Samantha Capon
Australian Rivers Institute - Griffith University
Phone: 0402 217 899
Email: s.capon@griffith.edu.au

Brendan Edgar
Phone: 0419 781 676
Email: brendan.edgar@gmail.com