

of sea ice has changed the preferred ecology of Adelie penguins, which have moved south as a consequence. In contrast, Gentoo and Chinstrap penguins, which prefer the ecology typical of habitats without sea ice, are thriving along the Peninsula.

### Has climate change happened before in Antarctica?

Ice cores from the Antarctic ice sheet give clues to past global climate that can help predict future climate. Results indicate that while there have been significant climate changes in the past, the current rate of change to the global climate is unusual, with atmospheric concentrations of CO<sub>2</sub> and methane (CH<sub>4</sub>) at unprecedented levels relative to the last 800,000 years. Furthermore, the concentrations of CO<sub>2</sub> and CH<sub>4</sub> are increasing at rates that have not been seen in the geologically recent past. This historic evidence points to previous warm periods causing rapid loss of ice masses, shifts in ocean circulation, locally enhanced biological production, and a raising of sea level 4-6 metres above today's level. Ice core studies have also indicated that atmospheric circulation patterns over Antarctica and the Southern Ocean have abruptly changed several times in the past 11,000 years. Yet studies of sediments under newly lost ice shelves suggest that the recent ice shelf loss is unprecedented in the last several thousand years.

### Looking forward

A doubling of greenhouse gasses in the next century could see Antarctica warm by around 3°C. It is probable that the ozone hole will heal over the next 60 years, but with the assumed increase in greenhouse gasses, polar vortex winds are expected to continue to increase. Sea ice is expected to decrease by a third, with most melting in the western sector, while melting from the West Antarctic ice sheet is likely to contribute a global sea level rise of up to 1.4 metres by 2100. Snowfall will increase across the continent offsetting sea level rise by a few centimetres.

Research to understand the mechanisms and implications for climate change in Antarctica is underway, but much more work is needed to provide us with more refined predictions of what is likely to happen and when. This includes research to answer specific questions, and long-term monitoring of the Southern Ocean and terrestrial environment to



provide the data to underpin our understanding of what is happening and forecasts of what may happen next. This research will help policy makers and planners make sensible practical decisions not only for protecting Antarctica, but also to prepare all of us for a changing environment wherever we live.



### Become an “Ambassador for Antarctica” and a steward of the global ecosystem

IAATO recognizes that modern climate change is a significant threat to the Antarctic environment and has established a working group to promote awareness and understanding of climate change in the Antarctic resulting from human activities worldwide, and to develop advice for IAATO Members to be climate-change friendly.

Experiencing Antarctica first hand is a privilege for all of us who visit, including you, your crew, staff and the science community. Having no native population, Antarctica needs Ambassadors who will champion this unique environment in a global context. We encourage you to take part and follow developments in the news and in your governments regarding the science and management of climate change, particularly as it affects Polar Regions. Learn more about climate change, its implications for the global commons and what you can do to help minimise and mitigate the changes.

\* Scientific Committee on Antarctic Research (2009), Antarctic Climate Change and the Environment. Edited by Turner, J., Bindshadler, R.A., Convey, P., Di Prisco, G., Fahrbach, E., Gutt, J., Hodgson, D.A., Mayewski, P.A., and Summerhayes, C.P., Cambridge, UK. The full ACCE report and supporting documents are available to download from:  
<http://www.scar.org/publications/occasional/acce.html>

A summary of the report's Key Findings is available to download from:  
[http://www.scar.org/publications/occasional/ACCE\\_top\\_10\\_points.pdf](http://www.scar.org/publications/occasional/ACCE_top_10_points.pdf)

## Climate Change in Antarctica - Understanding the Facts



IAATO Fact Sheet Summarising the Antarctic Climate Change and the Environment Report (ACCE)\*

[www.iaato.org](http://www.iaato.org)

## Introduction

Antarctica is a crucial part of the Earth system. The climatic, physical and biological properties of the continent and surrounding ocean are closely linked to the Earth's environment through ocean and atmosphere circulation and exchange of globally produced carbon dioxide (CO<sub>2</sub>) and other greenhouse gases. Antarctica contains 90% of the world's ice and 70% of the world's fresh water. It also holds high-resolution records of past climate change and sensitive biological indicators of contemporary change.

Evidence of climate change can be found throughout the world including in the Antarctic. While Antarctic and global climate have continued to change over millennia, it is the rate of modern climate change that is unusual.

## How do we know what is happening?

The latest findings compiled by the Scientific Committee on Antarctic Research (SCAR) published in a 2009 review\* outlined the unprecedented increase in global carbon dioxide levels and the connections between human-induced global change and natural variability, focusing on the state of Antarctica's climate and its relationship to the global climate system.



Photo ©David Rootes/ALE

The review explained in detail the complexities of the changing environment and pointed to:

- The extraordinary finding that the ozone hole has shielded much of the continent from much of the effects of global warming;
- A rapid warming of the Antarctic Peninsula and the Southern Ocean;
- Rapid glacial ice loss in parts of Antarctica but an increase in sea ice around the eastern side of the continent;
- Changes in the abundance and distribution to Antarctica's flora and fauna resulting from changing feeding and breeding habitats driven by the changing climate.

## A positive effect of the Ozone Hole?

The Antarctic "ozone hole" – a human-caused environmental impact – was one of the most significant scientific discoveries of the last century and has had a profound impact on the Antarctic environment, including increased biologically harmful UV-B radiation.

However, the ozone hole has intensified the polar vortex -- a ring of winds around Antarctica. These westerly winds have increased by about 15% over the Southern Ocean and, consequently, have acted to further isolate much of Antarctica from the rest of the planet. As a result there has been little change in either surface temperature or levels of snowfall across most of the continent over the last 30 years. This isolating effect of the polar vortex has also resulted in an increase in sea ice coverage in the Ross Sea and East Antarctic region since the 1980s.

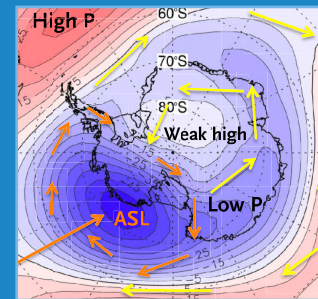
## What is happening in the Peninsula?

The exception is the Antarctic Peninsula that juts northwards from the continent into the path of the polar vortex. Here, the increased winds have resulted in distinct warming of average summer and autumn temperatures as they bring relatively warm and moist air from the oceans onto the

Peninsula. Those warm winds have led to a marked decrease in sea ice cover and increased precipitation there, and approximately 90% of the Peninsula's glaciers have retreated over recent years. The loss of sea ice along the Peninsula balances the growth in the Ross Sea, the net effect for the whole continent being a 10% increase in sea ice since 1980.

The warming has also affected floating ice shelves around the peninsula, and several have collapsed in recent years, notably the Larsen B ice shelf, which disappeared suddenly in March 2002.

The distribution and success of the Peninsula's plant and animal life has also been affected by this warming. Plant communities have expanded rapidly and newly available land has been colonised by plants and animals. Plant and animal communities have also become more susceptible to invasion from non-native species, which – fostered by the warmer, wetter climate – can have detrimental effects on the local ecosystems.



source: J. Turner / ACCE report

## What is happening to the Southern Ocean?

The Southern Ocean is one of the world's major sinks of global atmospheric CO<sub>2</sub>. In recent decades, however, it has become less effective in absorbing global CO<sub>2</sub> because the increasing westerly winds have caused an upwelling of CO<sub>2</sub>-rich water from other areas, minimizing its capability to absorb additional CO<sub>2</sub>.

In addition, waters of the Antarctic Circumpolar Current have warmed around 0.2°C per decade, which is more than the global ocean average. It is not yet clear what effect that is having on open ocean ecosystems.

In the Amundsen Sea area off West Antarctica, the stronger winds of the Southern Ocean have forced more welling up to the surface of deep, warm subsurface water. This warm water has penetrated beneath West Antarctica ice shelves causing them to erode. Those ice shelves act as "brakes" for nearby glaciers. As the shelves thin, the glaciers gather speed and drain ice from the main ice sheet quicker than during previously recorded periods. This process is causing the enormous (50 km wide) Pine Island Glacier and its neighbouring glaciers to speed up in that area, putting the West Antarctic ice sheet at risk. Collapse of that ice sheet could discharge as much ice into the sea as the melting of Greenland, though that is not envisaged in the present century.

## How are these changes affecting the Marine ecosystems?

The Southern Ocean's change in chemical composition and temperature has implications for the marine ecosystem. The acidification of the ocean (caused by the absorption of global CO<sub>2</sub>) is expected to have a significant effect on ecologically key species (e.g. planktonic snails whose shells will dissolve in more acidic waters), and this will have cascading consequences through the ecosystem.

Equally, if seawater temperatures continue to rise, some endemic species may be able to adapt, but others may become extinct if their physiological and ecological limits are exceeded; then the marine ecosystem would be more susceptible to competition from non-native species.

The changing patterns of sea ice also affect distribution of wildlife. In the Peninsula waters and around South Georgia, krill stocks have declined as a consequence of loss of sea ice. This decline is likely to affect the populations of birds, seals, and whales. The loss