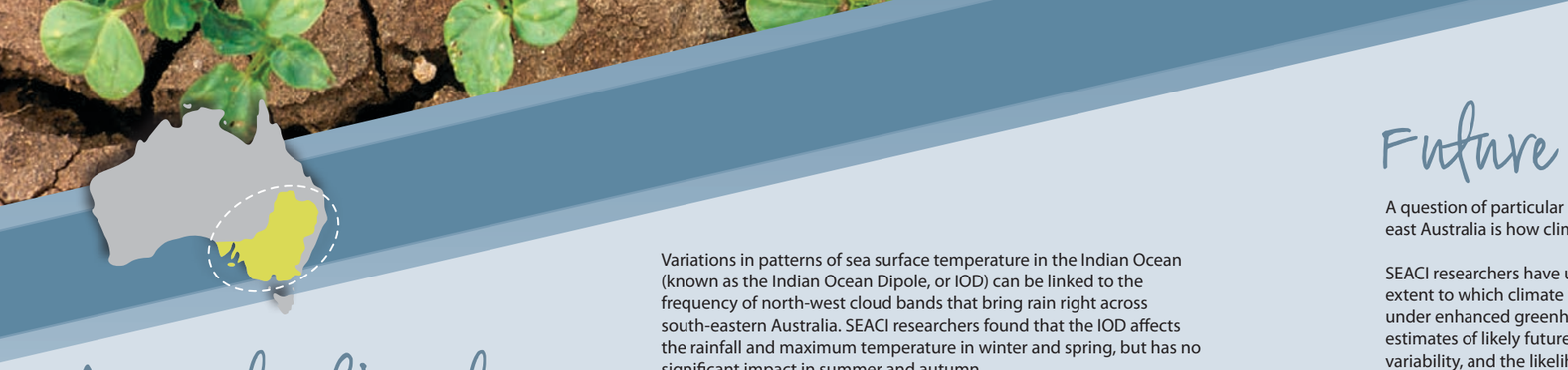
South Eastern Australian
Climate initiative

South-eastern Australia is one of the country's most valuable primary production areas. The Murray–Darling Basin alone produces over one-third of Australia's food supply and generates 40% of the nation's agricultural income, with 70% of Australian irrigation occurring in the region.

Over the past 12 years there has been an apparent shift to a warmer and drier climate here, which has had major impacts on our water resources. These changes have come about earlier and to a larger extent than climate change scientists have generally expected.

Understanding climate variability in the region, as well as the longer term climate changes, is critical for the future planning for water resources, agriculture, communities and the environment across south eastern Australia.

Answering questions about climate in South Eastern Australia



Current climate

To better understand the current climate, it is necessary to understand the major influences on climate over a range of time-scales, the relationships between these influences, and whether they have changed over time.

SEACI researchers have assessed the current level of knowledge about climate variability and climate change over south-eastern Australia by assembling and reviewing information throughout published literature and databases, and by analysing meteorological records for specific sites. They have also conducted experiments with global climate models to determine what factors have caused recent climate trends and shifts.


CSIRO Plant Industry/Carl Davies

How has climate changed and what is the current climate baseline?

The baseline climate used in many climate change studies is the period 1961–1990. However, for south-eastern Australia this is the wettest period over the last century, and is not representative of the current climate of the region.

The last decade has seen a prolonged period of reduced rainfall, especially in autumn. The past eight years (including 2008) have all seen autumn totals below the previous long term average (1961 to 1990). In recent years spring rainfall has also been declining steadily.

Eleven of the past 12 years rank among the 12 warmest years since records began and Australia has experienced warmer than average mean annual temperatures for 17 of the past 19 years.

SEACI research suggests that in the absence of definite evidence of a permanent climate shift, the current baseline is better defined by using the longest possible climatic record including prior dry period (such as the 1940s) as well as the current dry conditions. However, if it is assumed that most of the recent change in climate is due to a long-term trend (probably global warming) there is also a case for using just the last 10-15 years as a baseline, since this would most likely be more representative of the future than the climate 30 to 40 years ago. Further research to determine the causes of recent climate changes is required.

What are the major influences on climate in south-eastern Australia?

The El Niño Southern Oscillation (ENSO) has a significant effect on the climate of eastern Australia. Major droughts are almost invariably linked to ENSO events, when the sea surface temperature rises in the eastern Pacific Ocean and cools in the west around Indonesia. SEACI researchers have also confirmed that warm dry conditions occur in spring during ENSO events.

Variations in patterns of sea surface temperature in the Indian Ocean (known as the Indian Ocean Dipole, or IOD) can be linked to the frequency of north-west cloud bands that bring rain right across south-eastern Australia. SEACI researchers found that the IOD affects the rainfall and maximum temperature in winter and spring, but has no significant impact in summer and autumn.

The Southern Annular Mode (SAM) refers to the north-south movement of the band of westerly winds south of Australia. SEACI researchers determined that the SAM has a significant effect on rainfall and minimum temperature in all seasons except autumn.

It was found that the influences of ENSO, IOD and SAM are at their weakest in autumn, the season where the largest rainfall decline has been observed.

Rainfall in south-eastern Australia in autumn and winter is related to the mean sea level pressures over southern Australia. These pressures, in turn, are related to the intensity of the sub-tropical ridge, which is a belt of high pressure located in the mid-latitudes (around 30 degrees south). The sub-tropical ridge is associated with the southern hemisphere Hadley cell, which is a circulation pattern that transports excess heat from the equator towards temperate latitudes. Pressures along the sub-tropical ridge have increased during the 20th century, and this intensification of the ridge appears to be related to global warming. This intensification explains about 70% of the observed rainfall decline in south-eastern Australia.

Understanding the relationship between rising global temperature and the sub-tropical ridge intensification will require additional research. Furthermore, the relationships between changes in the Hadley circulation, the ENSO, IOD and SAM have not yet been clarified and remain active areas of research.

The sea surface temperature in the Tasman Sea also affects weather systems such as east-coast lows. While SEACI researchers have determined that the Tasman Sea has an effect on temperature in all seasons, the effect on rainfall is less certain.


Murray-Darling Basin Authority

What are the causes of the dry conditions affecting parts of the study area over the past decade?

The dry conditions of the past decade in south-eastern Australia have led to a large reduction in stream-flow (39%) compared with the reduction in annual rainfall (13%). One of the reasons for the reduction in stream-flow appears to be that the rainfall reduction is mainly in autumn. This means that the land surface is not as moist when the winter rains come, so there is less winter run-off. Furthermore, there have been changes in the timing and nature of heavy rainfall events, which again affects how much rainfall eventually ends up contributing to stream flows.

Temperatures across south-eastern Australia have also been increasing in recent decades. This will cause greater heat stress on agricultural and natural ecosystems. For example, warmer temperatures may have contributed to increasing evaporation, thereby intensifying the impact of rainfall reduction on stream-flows. An initial analysis has suggested that a 1 degree increase in temperature could account for 15% of the stream-flow reduction over the past 50 years. However, further research on the relative impacts of changes in rainfall and temperature on stream-flows is required.

Main cover photo : CSIRO Land and Water/Gregory Heath
Front photo inserts, left: CSIRO Plant Industry, middle: CSIRO Land and Water/Gregory Heath, right:- Darling Basin Authority

Future climate

A question of particular importance for water managers in the south-east Australia is how climate change may affect future stream-flows.

SEACI researchers have used climate modelling to determine the extent to which climate in south-eastern Australia is likely to change under enhanced greenhouse conditions. The aim is to improve estimates of likely future changes in average climate, climate variability, and the likelihood of extreme events such as storms, and associated impacts on stream-flows.


CSIRO Land and Water/Willem Van Aken

How is climate likely to change over the next 25-65 years, and what's the likelihood of these changes?

SEACI researchers looked at the results from a number of climate models which provide simulations of future average conditions, inter-annual variability and extreme rainfall, temperature and evaporation events over the region. These results suggest that south-eastern Australia is likely to be warmer and drier in future decades, especially in the winter.

Hydrological modelling, driven by climate model projections under a mid-range emissions scenario, indicates that the mean annual run-off in 2030 is likely to change by between -30% and 0% with a median of -15% in the southern part of south eastern Australia and by between -25% and 20% with a median of -5% in the northern part.

The probabilities of changes in rainfall and temperature are available in the climate change projections for Australia developed by CSIRO and the Bureau of Meteorology through the Australian Climate Change Science Program. They are available at **www.climatechangeinaustralia.gov.au**.

A key issue requiring further investigation is why the observed changes in climate and stream-flow over the last decade are already greater than those projected by the model for the middle of this century.

How can methods for regional projections be improved so as to provide greater confidence for stakeholders?

While the magnitude of the actual projected changes remains somewhat uncertain, SEACI research suggests that this uncertainty can be reduced by careful selection of the climate models used to prepare the projections. Furthermore, SEACI researchers can provide greater regional detail on future climate projections and this information can also potentially reduce the uncertainties in managing resources.


CSIRO Plant Industry

Seasonal Forecasts

A seasonal climate forecast indicates how rainfall or temperature in a coming season is likely to be different from the average weather calculated over a long period, such as 30 years. Because the climate system is so complex, it is impossible to exactly predict the future seasonal climate, so climate forecasts are generally expressed as the probability that rainfall or temperature will be below normal, near normal, or above normal.

SEACI researchers have investigated whether reliable seasonal forecasts (3–12 months ahead) can be developed for south-eastern Australia, and whether these can be applied to forecast stream-flow and crop yields. The researchers evaluated the performance of existing systems which forecast rainfall and temperature, developed and evaluated new forecasting systems, and developed and tested ways of improving forecasts of stream-flows and crop yields.

Can reliable methods of forecasting climate 3-12 months ahead be developed for south-eastern Australia?

The coupled atmosphere–ocean–land climate model (POAMA) has been refined during the SEACI program to improve the accuracy of seasonal forecasts. For most of Australia (but especially south-eastern Australia) the model is now more accurate than the current operational seasonal outlook system of the Bureau of Meteorology. The improved accuracy, especially from autumn through spring, is mostly due to improved atmospheric initial conditions used by the model that were developed during SEACI and by the ability to better capture information about El Niño Southern Oscillation events. Planned improvements in the model are expected to further increase the accuracy of the seasonal forecasts.


CSIRO Land and Water/Willem Van Aken

Can these new forecast methods be applied to forecast stream-flow and crop yields?

SEACI researchers assessed the economic utility of seasonal climate forecasts from a number of global climate models (including POAMA) for on-farm decision making. The results varied from farm to farm, because of regional differences in soil type. The results also depended on how well each model could predict El Niño Southern Oscillation events

While global climate models provide the basis of future improvements in seasonal climate prediction, it was found that useful information can be obtained from statistical methods based on the relationship between rainfall and El Niño Southern Oscillation in south-eastern Australia. An improved statistical seasonal climate prediction system applied to the forecasting of stream-flow in the upper Murrumbidgee and northern Victoria was found to be useful for hydrological purposes. This system can be modified to include the output of a global climate model such as POAMA.

About the South Eastern Australian climate Initiative

Photo credits:
Above, left: CSIRO Land and Water/ Gregory Heath, right: Murray-Darling Basin Authority

The South Eastern Australian Climate Initiative (SEACI) was established in 2005 to answer some of the questions relating to the causes and impacts of climate change and climate variability across south eastern Australia. The SEACI study area covers the Murray-Darling Basin, Victoria and southern South Australia, including the agricultural areas of Eyre Peninsula.

Research in the three and a half year, $7.5 million program is being undertaken by CSIRO and the Bureau of Meteorology. The program is managed by the Murray–Darling Basin Authority, which also provides funding, along with the Victorian Department of Sustainability and Environment, the Commonwealth Department of Climate Change, and the Managing Climate Variability Program.

Building on the existing knowledge available from many other climate programs, both in Australia and internationally, SEACI aims to deliver a better integrated understanding of climate change and climate variability across south eastern Australia. Information collected though SEACI research will support a wide range of planning, management and policy decisions for agriculture, water, natural resources and climate change risk management by communities, industry and governments.

For more information:

Email **seaci@mdba.gov.au**
Visit **www.seaci.org**

Australian Government

MURRAY–DARLING BASIN AUTHORITY

Australian Government
Department of Climate Change

Australian Government
Bureau of Meteorology

State Government Victoria
Department of Sustainability and Environment

MANAGING CLIMATE VARIABILITY R&D PROGRAM

CSIRO