Hydrology
Climate Change Impact Snapshot

Overview of Impacts on **NSW** Hydrology

NSW is projected to undergo changes in the hydrological processes of surface runoff and groundwater recharge:

- Surface runoff is water that flows over the land rather than soaking into the soil;
- Groundwater recharge is the flow of water into the groundwater system.

Surface runoff:

- In the near future, southern areas of NSW are likely to have small reductions in runoff while central and northern areas of the state have small increases.
- In the far future, more surface runoff is likely across much of the state with the exception of some southern areas of NSW which are likely to have less runoff.
- Across most of NSW, higher surface runoff in autumn months is projected due to higher summer and autumn rainfall.
- Large reductions in surface runoff are likely in the alpine areas of southern NSW
- In southern parts of NSW, there is considerable drying during spring months resulting in less surface runoff.

Groundwater recharge:

- In the near future, less recharge is projected across much of NSW, especially in the south-east of the state.
- Considerably less recharge is likely in alpine areas.
- In the far future, more recharge is likely across much of the state with the exception of alpine areas, where very large reductions in recharge are projected.
- In the far future, the majority of models project increases in recharge in summer, autumn and winter, with the largest increases in summer months.

Climate Change Impact Snapshot

Climate Change Impact Research Program (CCIRP)

This impact report is part of the NSW Climate Change Impact Research Program (CCIRP). The CCIRP aims to understand the biophysical impacts of climate change in NSW using the climate change projections from the NSW and ACT Regional Climate Modelling (NARCliM) project. CCIRP is designed to ensure the research delivered meets the information needs of the NSW community. The CCIRP program is ongoing and will continue to provide updated information on the likely impacts of climate change in NSW.

NSW and ACT Regional Climate Modelling Project (NARCliM)

The climate change projections in this impact snapshot are from the NSW and ACT Regional Climate Modelling (NARCliM) project. NARCliM is a multi-agency research partnership between the NSW and ACT governments and the Climate Change Research Centre at the University of NSW. NSW Government funding comes from the Office of Environment and Heritage (OEH), Sydney Catchment Authority, Sydney Water, Hunter Water, NSW Office of Water, Transport for NSW and Department of Primary Industries.

The NARCliM project has produced a suite of 12 regional climate projections for south-east Australia spanning the range of likely future changes in climate. NARCliM is explicitly designed to sample a large range of possible future climates. The NARCliM project used a "business as usual" scenario (IPCC A2 scenario) consistent with international modelling approaches. This scenario assumes global development and population continues along current trajectories.

Future climate change projections are compared to the baseline modelled climate (1990–2009). Interpreting climate projections can be challenging due to the complexities of our climate systems. 'Model agreement', that is, the number of models that agree on the direction of change (for example increasing or decreasing rainfall) is used to determine the confidence in the projected changes. The more models that agree, the greater the confidence in the direction of change.

NARCliM has produced projections for:

1. The **near future** (2020-2039): these projections represent the best estimate of future climate by **2030**, even with significant global mitigation measures.
2. The **far future** (2060-2079): these projections are more sensitive to changes in global emissions but still represent the current best estimate of our future climate by **2070**.

Go to climatechange.environment.nsw.gov.au for more information on the modelling project, methods and technical reports.

Impact Science Technical Reports

The Climate Change Impact Snapshot reports are based on detailed technical reports. The 'Climate change impacts on surface runoff and recharge to groundwater in New South Wales' Technical Report details the results of the impact science research and can be accessed from the AdaptNSW website: climatechange.environment.nsw.gov.au

The snapshots provide descriptions of climate change projections for two future 20-year periods: near future or 2030, and far future or 2070 and represent the average of the two 20 year periods 2020-2039 and 2060-2079.

The maps in the snapshots represent an average of 12 models. The full range of variability is discussed in the technical report.

Help on how to interpret the maps and graphs in this report is provided in Appendix 1.

Introduction and current status

What is surface runoff and groundwater recharge?

Surface runoff is the water that flows over a land surface instead of being intercepted by vegetation or soaking into the soil. Factors that influence the relationship between rainfall and runoff include slope, current soil moisture conditions, soil permeability, vegetation cover, dead litter cover and soil surface properties.

Recharge to groundwater is the flow of water into a groundwater system from above. The infiltration of rainfall and the downward percolation of water through the soil profile can move below plant roots and eventually reach the water table. Volumes of recharge are influenced by soil properties such as permeability and vegetation properties such as root depth and density.

NSW hydrological system

NSW is divided into three major drainage divisions: coastal catchments, inland catchments (the Murray–Darling Basin) and the far north-west (Figure 1).

Coastal catchments in NSW have their headwaters in the Great Dividing Range and drain to the coast. Many flow into estuaries that provide spawning grounds for aquatic creatures and vital habitat for migratory birds. They are valued areas for tourism, recreation, commercial users and cultural activities. This offers many challenges for natural resource managers with competing economic and environmental values. Coastal regions are under the most pressure from population growth and land-use change. Growing populations and developments put increasing pressure on surface and groundwater resources. Pressures on groundwater are also higher due to a drier climate and increasing scarcity of surface water. Agriculture is a major water user along with town water supplies, domestic use, commercial and industrial users.

The hydrology of our coastal catchments shifts from north to south. North coast catchments have the highest and most variable rainfall and stream flows. These catchments are located in the subtropics which are hotter, more humid and wetter with higher and more intense rainfall in summer, and drier winters. The presence of the Great Dividing Range produces higher rainfall along the entire coast associated with orographic rainfall processes.

Southern catchments are less developed than other coastal catchments and are largely uncleared. They sit within the temperate rainfall zone with more uniform and reliable rainfall. Rainfall intensity becomes less in southern areas. Southern catchments do not produce the same volume of runoff as northern catchments. Recharge can be high in southern areas due to the soaking nature of the rainfall, especially during winter months.

NSW catchments in the Murray–Darling Basin have their headwaters in the Great Dividing Range and flow west towards the Barwon and Darling rivers. Flows in many catchments have been affected by high water extraction rates for irrigation. Some catchments discharge into wetlands and may only join the Barwon–Darling system in flood events. The Macquarie River is an example of this. Agriculture is a major water user along with town water supplies and domestic use. These major catchments are heavily regulated with large dams used to supply irrigators and environmental flows.

Northern catchments in the NSW Murray–Darling Basin (Macintyre, Gwydir and Namoi) experience a subtropical climate pattern with intense summer rainfalls caused by monsoonal influences.

These catchments have extremely variable flows from year to year – smallest flows during droughts can be 1% of the average flow. Flows during wet periods can be many times more than average flows.

Central west catchments (Castlereagh, Macquarie and Lachlan) have a temperate and more uniform rainfall pattern. In some years, monsoonal summer rainfall systems influence flows in these catchments. In other years, southern climate systems produce winter rainfall. It is an area of overlapping climatic influences from northern and southern rainfall mechanisms.

The southern Murray–Darling Basin catchments (Murray and Murrumbidgee) have their headwaters in alpine areas which produce more runoff than many other parts of the basin. Typically these rivers never cease to flow, with flow peaks very strongly aligned with the spring snow melt. Flows in the Murrumbidgee have been dramatically enhanced through the addition of water from the Snowy Hydroelectric Scheme. This scheme diverts water from the Snowy River into the Tumut River which connects to the Murrumbidgee River and supports downstream irrigators in the Murrumbidgee Irrigation Area.

Western areas of NSW are characterised by an arid climate with irregular rainfall and high evaporation. Many of the high flows in these river systems come from flood events in Queensland that slowly flow down the Barwon–Darling rivers. These flood events can cause substantial amounts of recharge to groundwater. Catchments in the far north-west of NSW lie outside the Murray–Darling Basin and either flow into Lake Eyre or are dispersed across the flat western landscapes.

Assessing the impacts of climate change on the water balance and hydrology is important because changes to the water cycle can have flow-on effects that impact salinity, erosion, water quality and aquatic biodiversity. The relationship between changes in runoff and a secondary impact can be complex. For example, increased runoff from a less saline part of a catchment will produce more dilution flow which can reduce salinity at the end of the catchment. In contrast, higher runoff in more saline parts of a catchment may increase wash-off of salts into the stream, increasing salinity.

Major river catchments

Figure 1: Major river catchments of NSW

Future changes in runoff

Changes in surface runoff will influence the availability of water resources by affecting flows into major dams and farm dams. This has more importance for catchments within the Murray–Darling Basin with many water users dependent on river flows. Management rules for water allocations and environmental flows may need to be assessed under a changing climate.

In coastal catchments, many town water supplies are sourced from river flows so water supply reliability under a changing climate is important. In an urban context, changes in surface runoff influence the design and operation of urban stormwater drainage systems.

Across much of NSW, surface runoff is projected to increase in both the near and far future (Figures 2 and 3). Largest increases are evident in the central west through to the northern tablelands. Large reductions in surface runoff are projected in both the near and far future for alpine areas in the south of the state.

The majority of models (7 out of 12) forecast increases in surface runoff in the near future. In the far future, 10 out of the 12 models agree that surface runoff will increase (Figure 4).

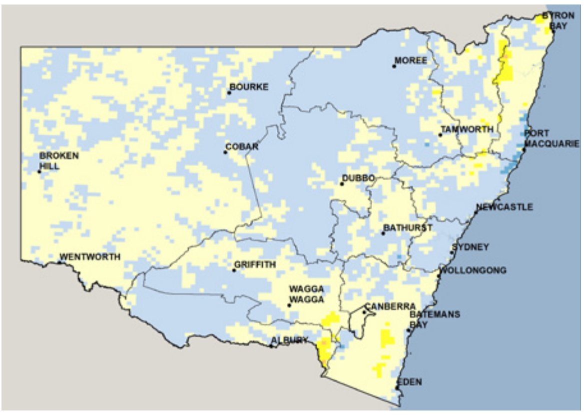


Figure 2: Near future (2020–2039) change in average annual surface runoff (mm) compared to the baseline period (1990–2009)

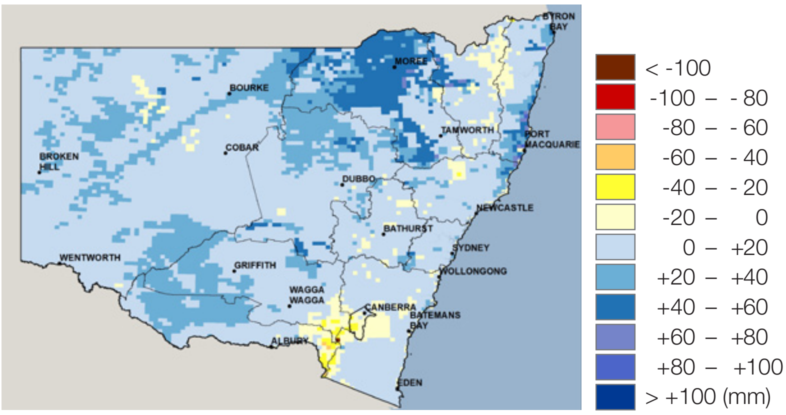


Figure 3: Far future (2060–2079) change in average annual surface runoff (mm) compared to the baseline period (1990–2009)

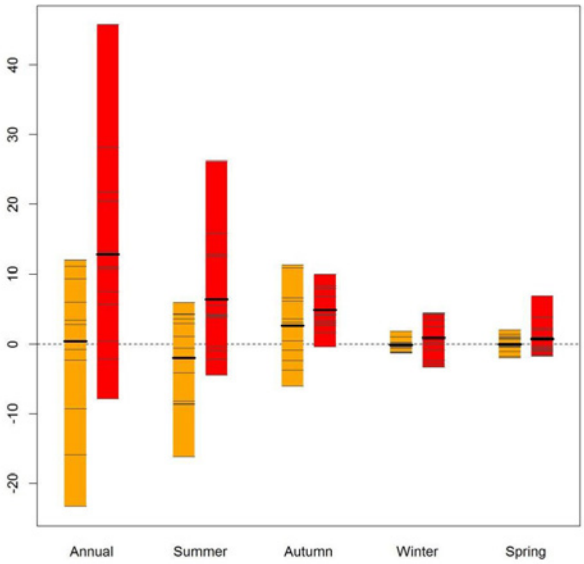


Figure 4: Projected changes in average annual surface runoff (mm), annually and by season (2030 yellow, 2070 red)

Seasonal Trends

Surface runoff in the near future

The models project considerable variation across the four seasons. In the near future, the majority of models (8 out of 12) project that autumn runoff will increase.

For other seasons, there is a slight decrease in summer runoff while winter and spring runoff is likely to remain unchanged.

In the near future, summer runoff is likely to increase in parts of central and southern NSW but decrease across much of the state, especially in north-eastern areas (Figure 5a). In contrast, autumn runoff is projected to increase across large areas of NSW (Figure 5b). Winter runoff is projected to increase slightly across southern NSW and along the Central Coast (Figure 5c), but decrease in other areas. The largest reductions in surface runoff are projected to occur across the southern parts of NSW during spring (Figure 5d).

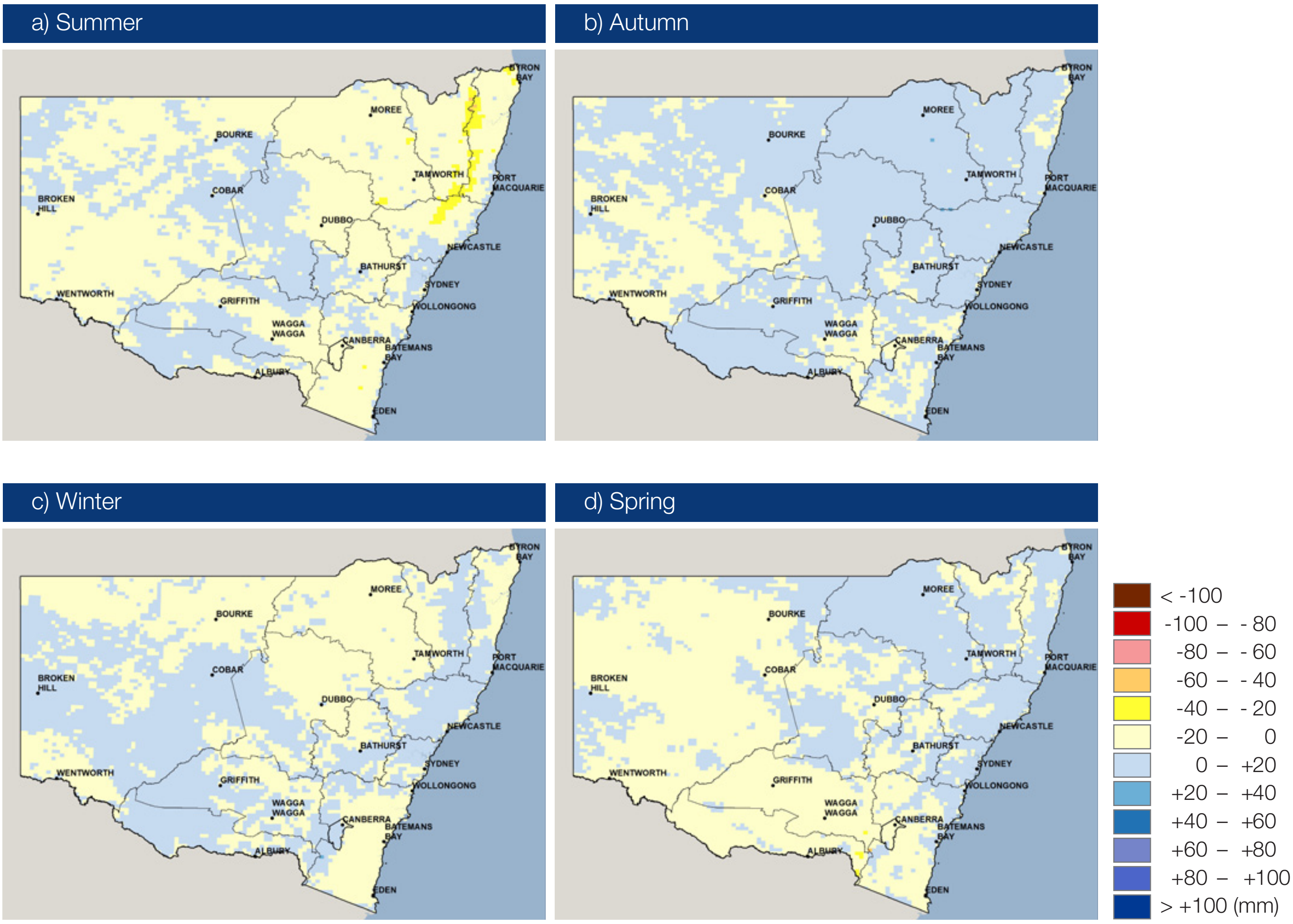


Figure 5: Near future (2020–2039) change in average a) summer, b) autumn, c) winter, d) spring surface runoff (mm) compared to the baseline period (1990–2009)

Surface runoff in the far future

Higher autumn rainfall in the far future is projected by 11 of the 12 models.

In the far future, the majority of models project increases in surface runoff during summer, autumn, and winter, with the largest increases in summer and autumn months.

In the far future the largest increases in surface runoff are in the northern parts of the state (Figures 6a and 6b). Winter runoff is projected to be lower in coastal areas with smaller increases elsewhere in NSW (Figure 6c). Larger reductions in spring runoff are likely in the south-east with much lower runoff in alpine areas of southern NSW (Figure 6d).

Implications

Changes in surface runoff will affect both urban and rural communities across NSW. Local Councils may need to consider the design of their storm water infrastrucutre to prepare for increases in surface runoff, especially in the far future. Changes in the seasonal patterns of rainfall and stream flow may impact the reliability of some town water supplies dependent on surface water extractions.

In a rural context, farmers growing annual pastures or winter crops usually have minimal groundcover in autumn leaving the soil surface exposed. Farmers may need to prepare for increased surface runnoff in autumn by ensuring adequate vegetation and groundcover to protect the soil. In southern parts of the State, some farmers may also be affected by less rainfall during spring affecting affecting spring growth of annual pastures or reducing yields of their winter crops.

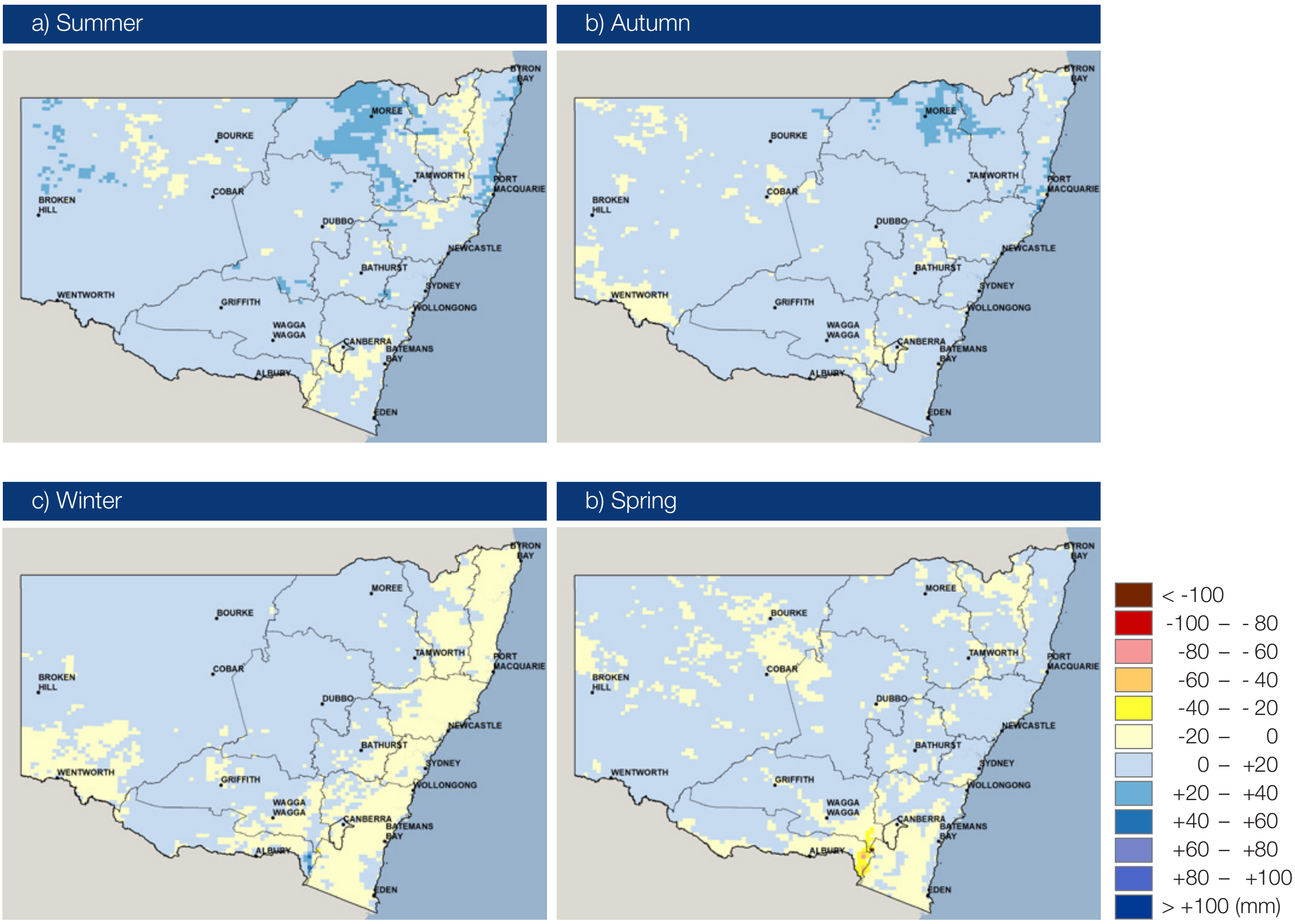


Figure 6: Far future (2060–2079) change in average a) summer, b) autumn, c) winter, d) spring surface runoff (mm) compared to the baseline period (1990–2009)

Future changes in recharge

Changes in recharge will influence groundwater levels, the availability of groundwater resources and the volumes of base flow in streams. Higher recharge will cause groundwater levels to rise and increase groundwater availability and/or discharge. Less recharge will lower groundwater levels and may cause some streams that are currently connected to groundwater (gaining streams) to become disconnected from groundwater (losing streams). Instead of a stream gaining surface flow from groundwater, it will lose surface flow to groundwater.

In the near future, less recharge is projected across much of NSW, especially in the south-east of the state (Figure 7). Considerably less recharge is likely in alpine areas. Some areas of western NSW do show a slight increase in recharge but these increases are relatively small.

In the far future, recharge is expected to increase across many parts of NSW. Some areas along the Great Dividing Range are likely to experience less recharge to groundwater. The largest impact is the dramatic reduction in recharge in alpine areas (Figure 8).

The majority of models (7 out of 12) project increases in recharge in the near future. In the far future, nine out of the 12 models agree that recharge will increase (Figure 9).

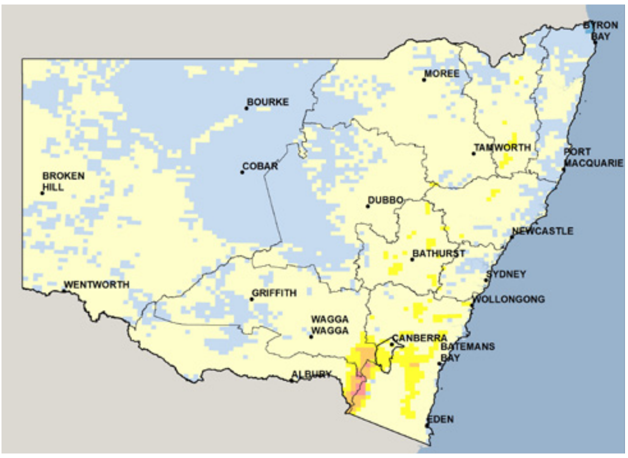


Figure 7: Near future (2020–2039) change in average annual recharge (mm) compared to the baseline period (1990–2009)

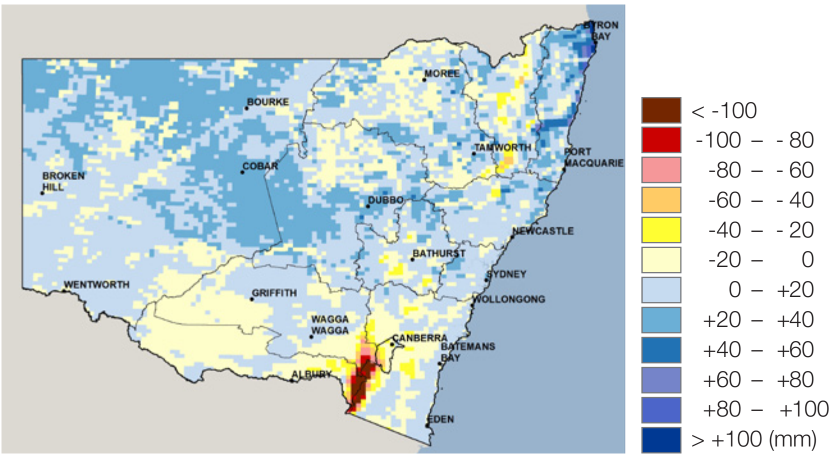


Figure 8: Far future (2060–2079) change in average annual recharge (mm) compared to the baseline period (1990–2009)

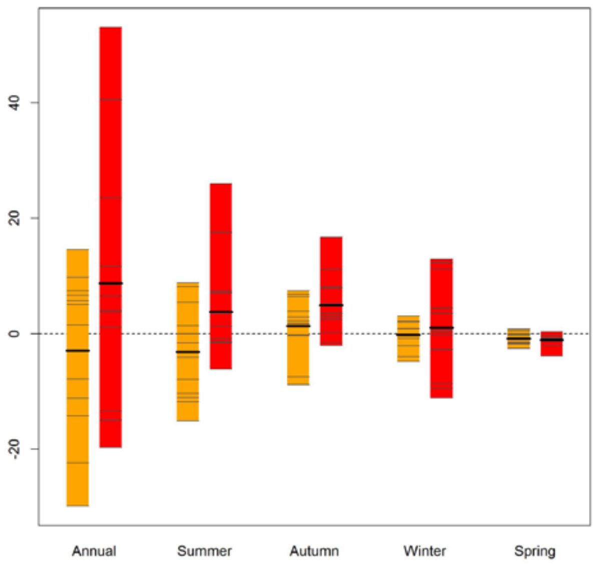


Figure 9: Projected changes in average annual recharge (mm), annually and by season (2030 yellow, 2070 red).

Seasonal Trends

Groundwater recharge in near future

The models project considerable variation across the four seasons. In the near future, there is less change in recharge compared to the far future.

In the near future, recharge during summer is likely to be lower in many parts of NSW (Figure 10a), especially along the western side of the Great Dividing Range. In autumn months there is a general trend for a small increase in recharge (Figure 10b), while in winter months a small decrease in recharge is evident (Figure 10c). The largest changes occur during spring with considerably less recharge in alpine areas (Figure 10d). There is a general drying trend with less recharge in spring across much of NSW with the exception of the north-east.

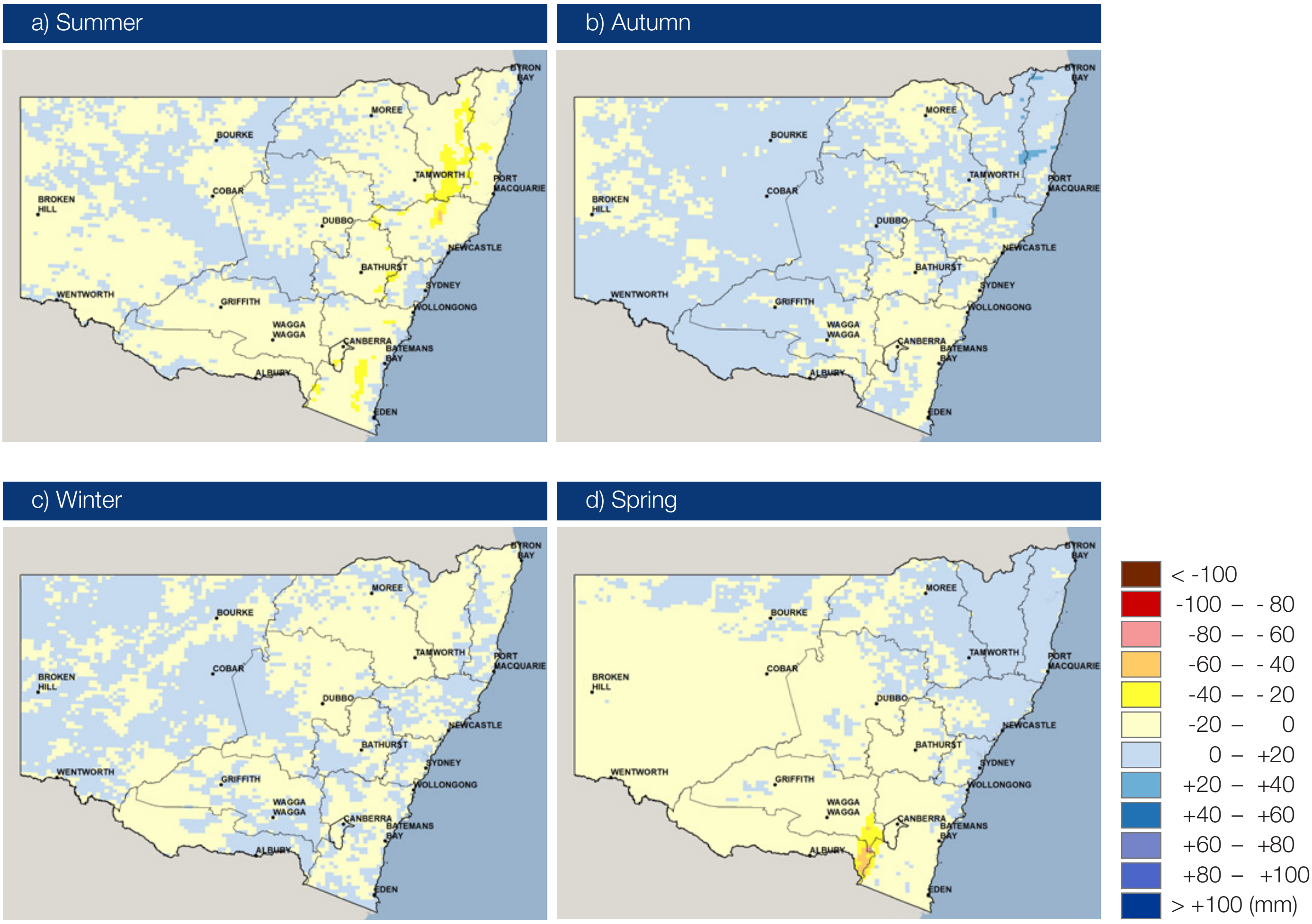


Figure 10: Near future (2020–2039) change in a) summer, b) autumn, c) winter, d) spring surface recharge (mm) compared to the baseline period (1990–2009)

Groundwater recharge in far future

In the far future, the level of agreement across the models is poorer compared with the near future, indicating more uncertainty in these projections (Figure 9). The majority of models project increases in recharge across NSW in the summer and autumn months (Figure 11a and 11b). In particular, higher volumes of recharge are likely in many parts of coastal catchments north of Newcastle.

During winter, recharge is likely to be lower especially in coastal areas and southern NSW (Figure 11c). Drier spring months with considerably less recharge are likely in southern NSW with large reductions in recharge projected in alpine areas (Figure 11d).

Implications

Volumes of recharge influence how much water can safely be taken from groundwater supplies. Changes in recharge will affect both urban and rural communities across New South Wales. Many remote communities and farmers rely on groundwater. The NSW Office of Water estimates approximately 11% of NSW's water supply comes from groundwater and is pumped from beneath the ground via bores and wells. Reductions in recharge in southern parts of the state may impact the reliability of groundwater supply. Areas with increased recharge have the potential to have increased volumes of groundwater discharge. This may interact with salt stores, potentially mobilising salt and causing land or stream salinity.

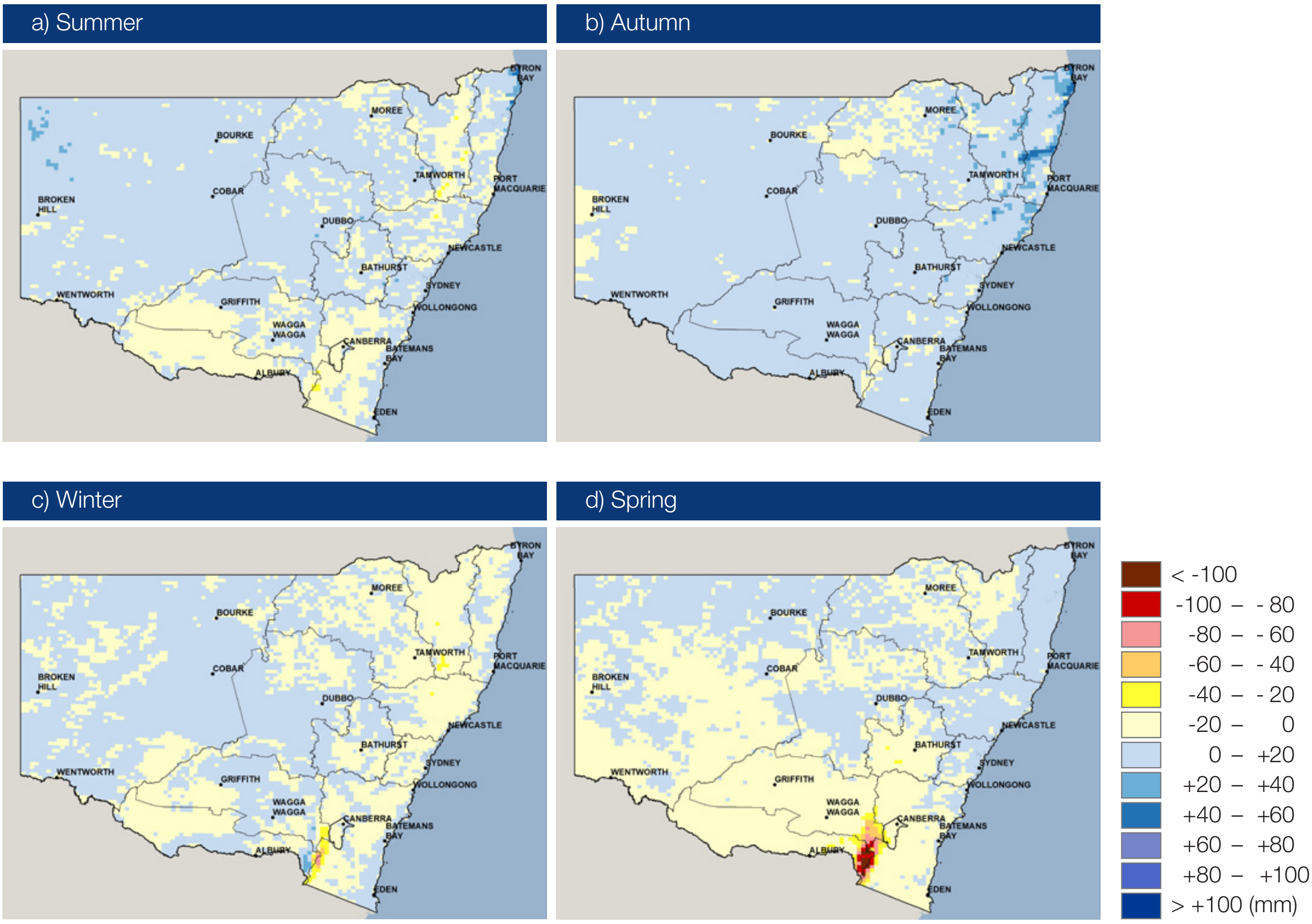


Figure 11: Far future (2060–2079) change in a) summer, b) autumn, c) winter, d) spring recharge (mm) compared to the baseline period (1990–2009).

Appendix 1 Guide to reading the maps and graphs

This document contains maps and bar graphs of the climate change projections, which are used to present the twelve model outputs as a central estimate calculated by averaging the results from the twelve models. The bar graphs show future projections averaged across the entire region and are not representative of any particular location within the region. For more detailed spatial information, maps are presented showing the central estimates of future projections. Below is information on what is displayed in the bar graphs and maps.

How to read the maps

The map displays modelled data in grids across NSW.

The colour of each grid is the AVERAGE of 12 models for that grid.

The State is divided into NSW Local Land Services regions.

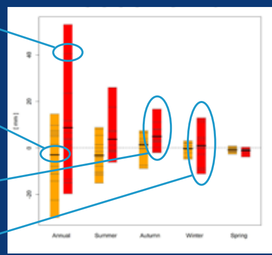
How to read the bar graphs

The thin grey lines are the **individual models**. There are 12 thin bars for each bar.

The thick line is the **average of all 12 models** for NSW.

The length of the bar shows the **spread of the 12 model values** for NSW.

Each bar represents the **average for NSW**. They do not represent a single location.



Note: The yellow bars represent near future scenarios (2020–2039), while the red bars represent far future scenarios (2060–2079).

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