Climate change – likely impacts

Queensland Rangelands Policy Dialogue 1-2 July 2019

Roger Stone

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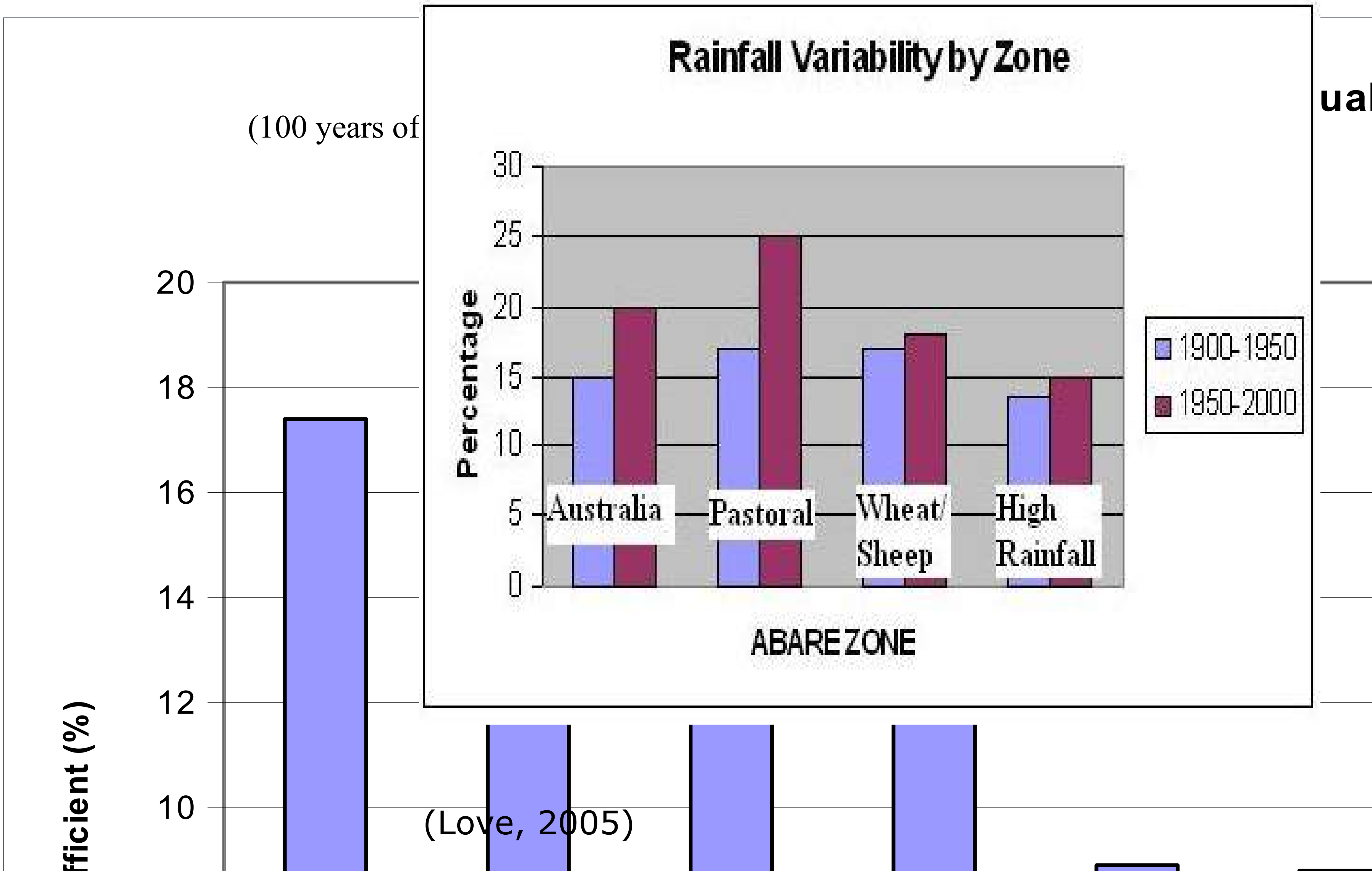
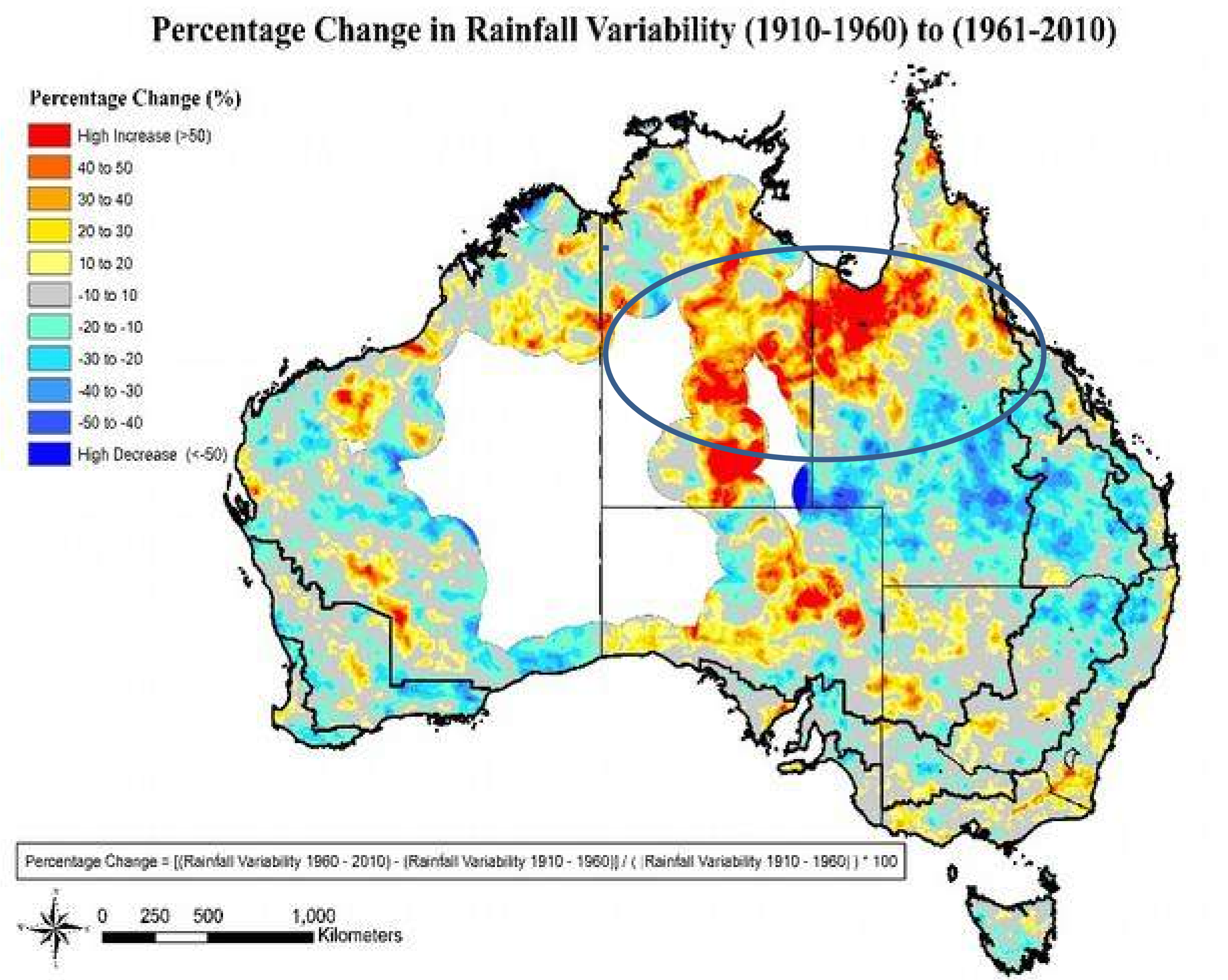
Climate issues dominate - Australia has the world's highest levels of year to year climate variability





Year-to-year rainfall variability increasing – especially in the Gulf (Cobon et al, 2019)

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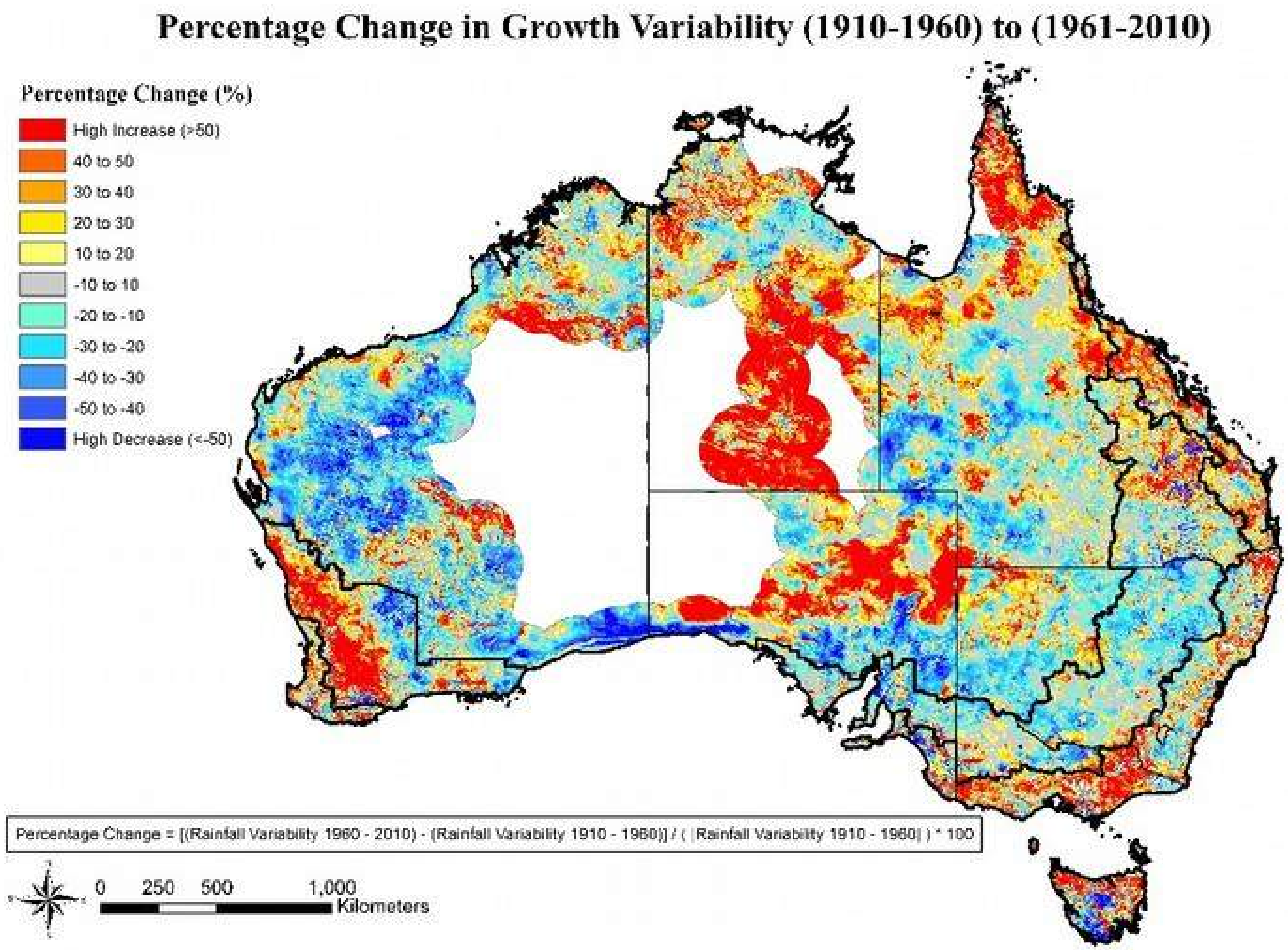
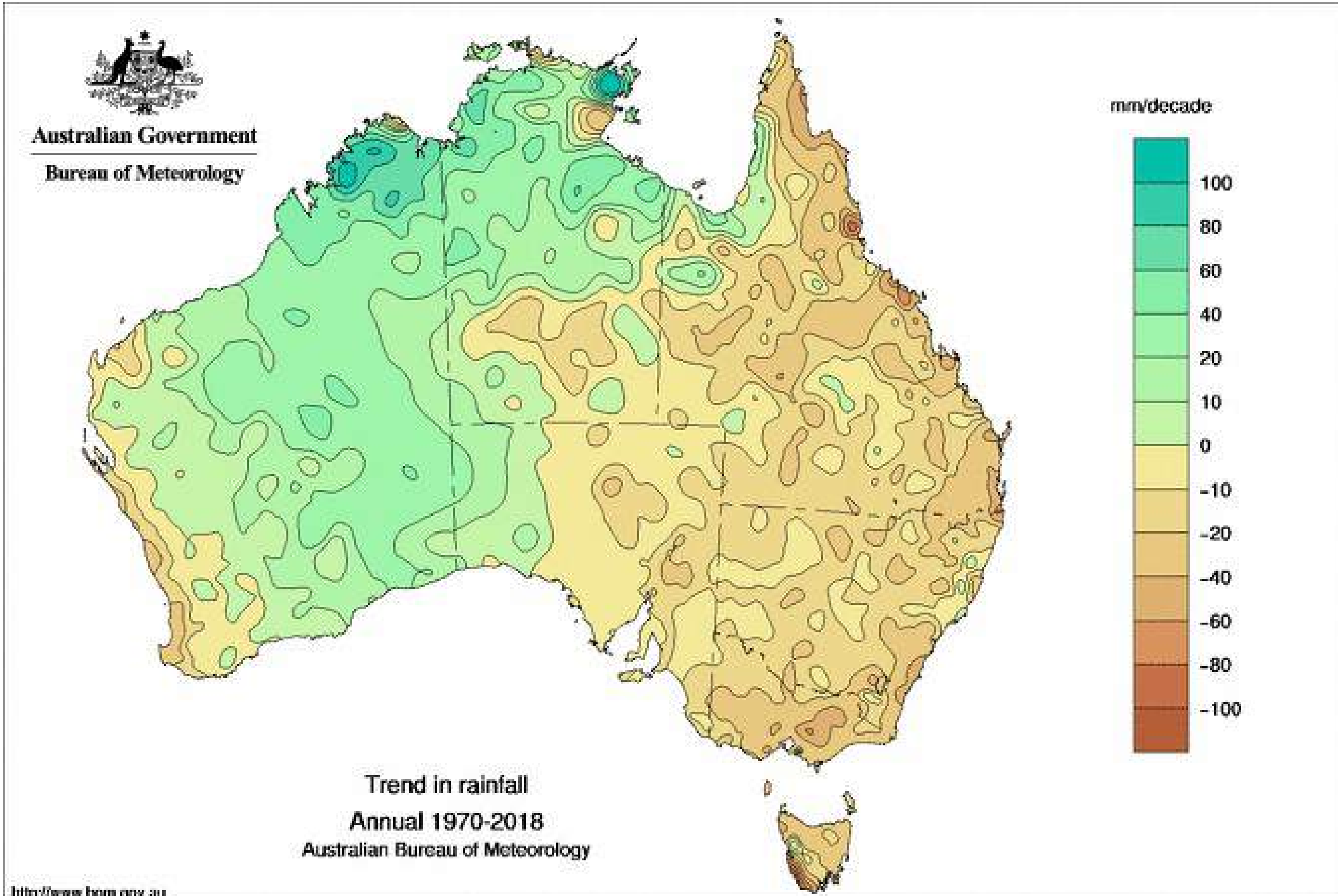
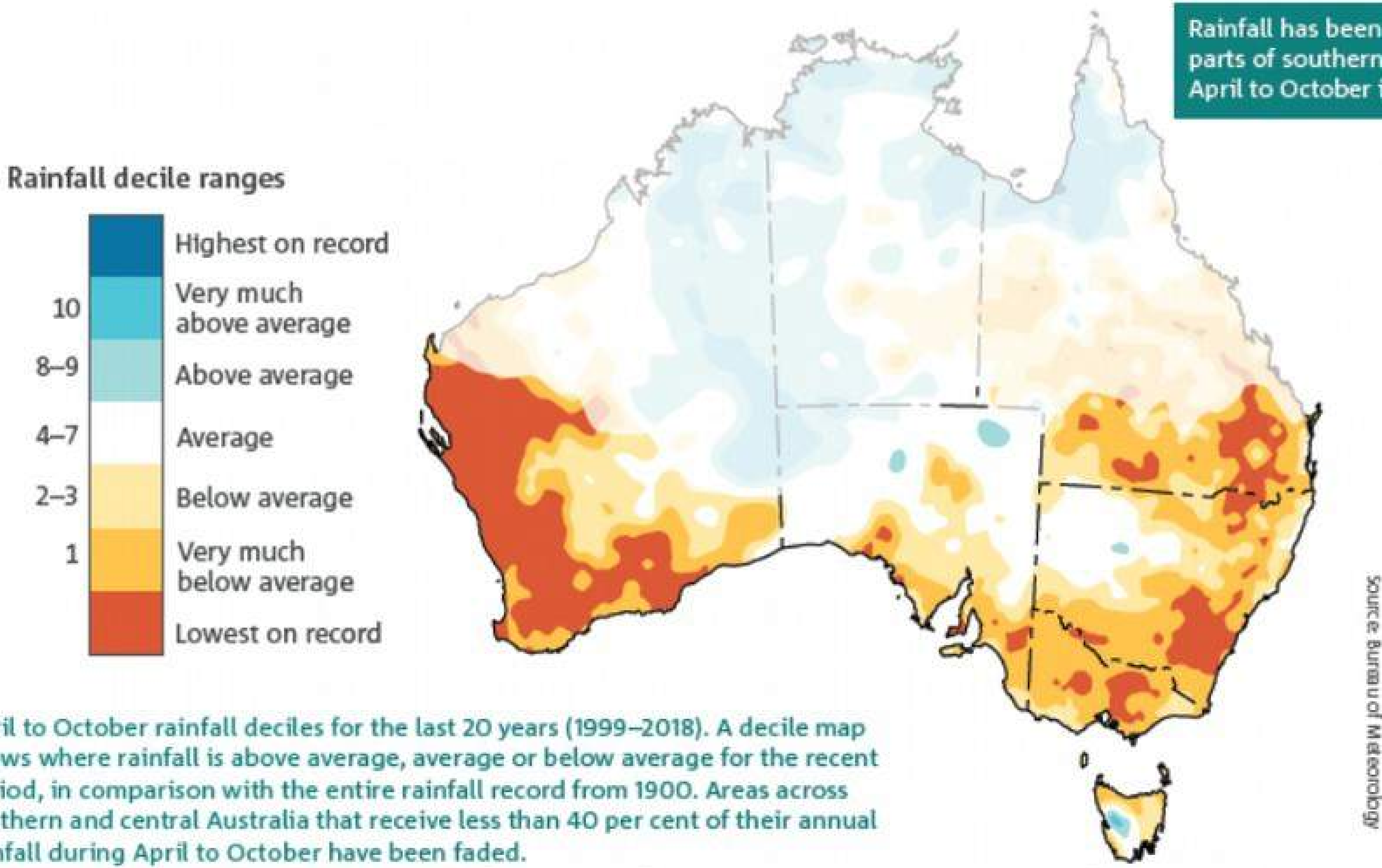


Year-to-year pasture growth variability increasing – regions shaded red (Cobon et al, 2019)

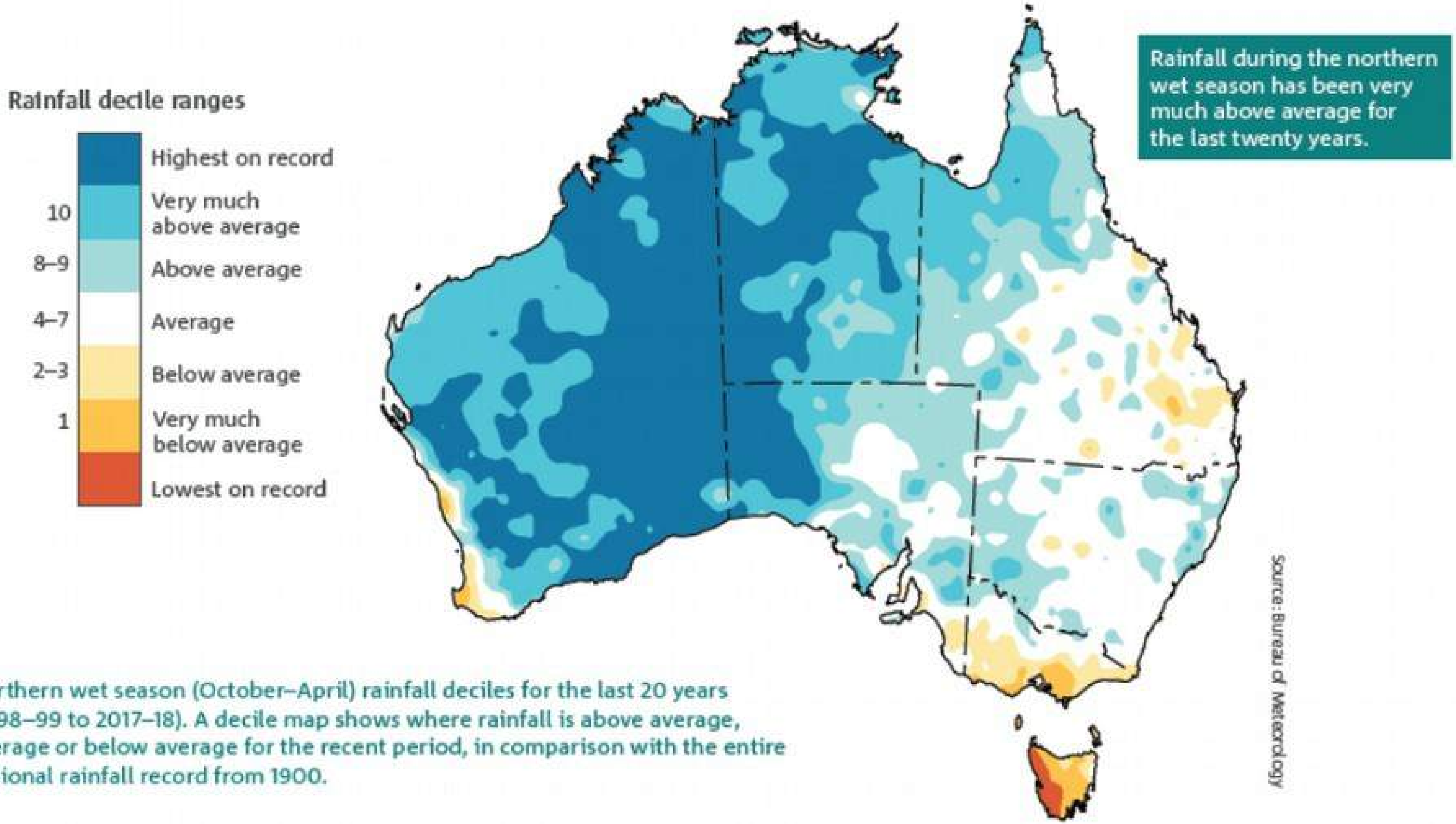


Issued: 10/01/2019

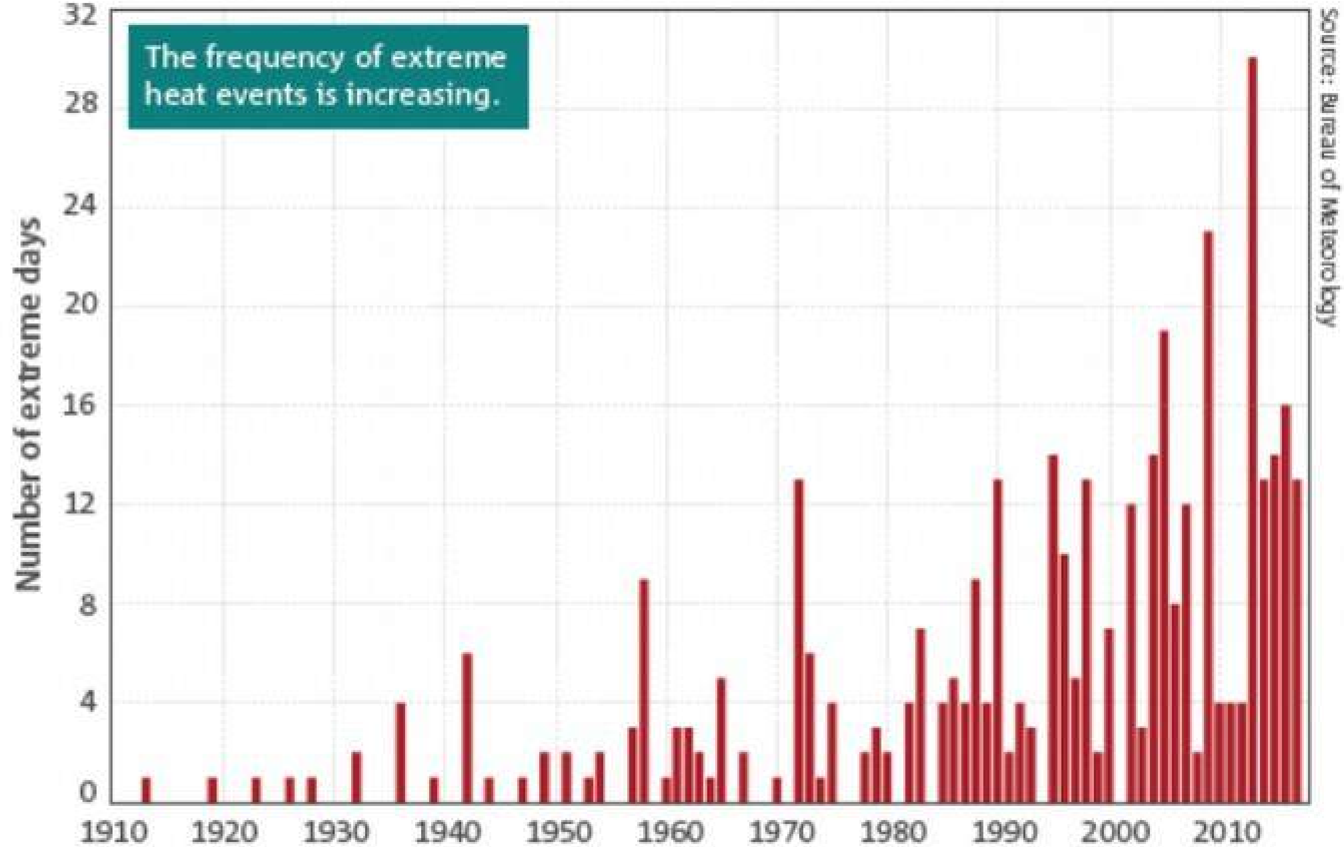
Rainfall has been very low over parts of southern Australia during April to October in recent decades.



April to October rainfall deciles for the last 20 years (1999–2018). A decile map shows where rainfall is above average, average or below average for the recent period, in comparison with the entire rainfall record from 1900. Areas across northern and central Australia that receive less than 40 per cent of their annual rainfall during April to October have been faded.

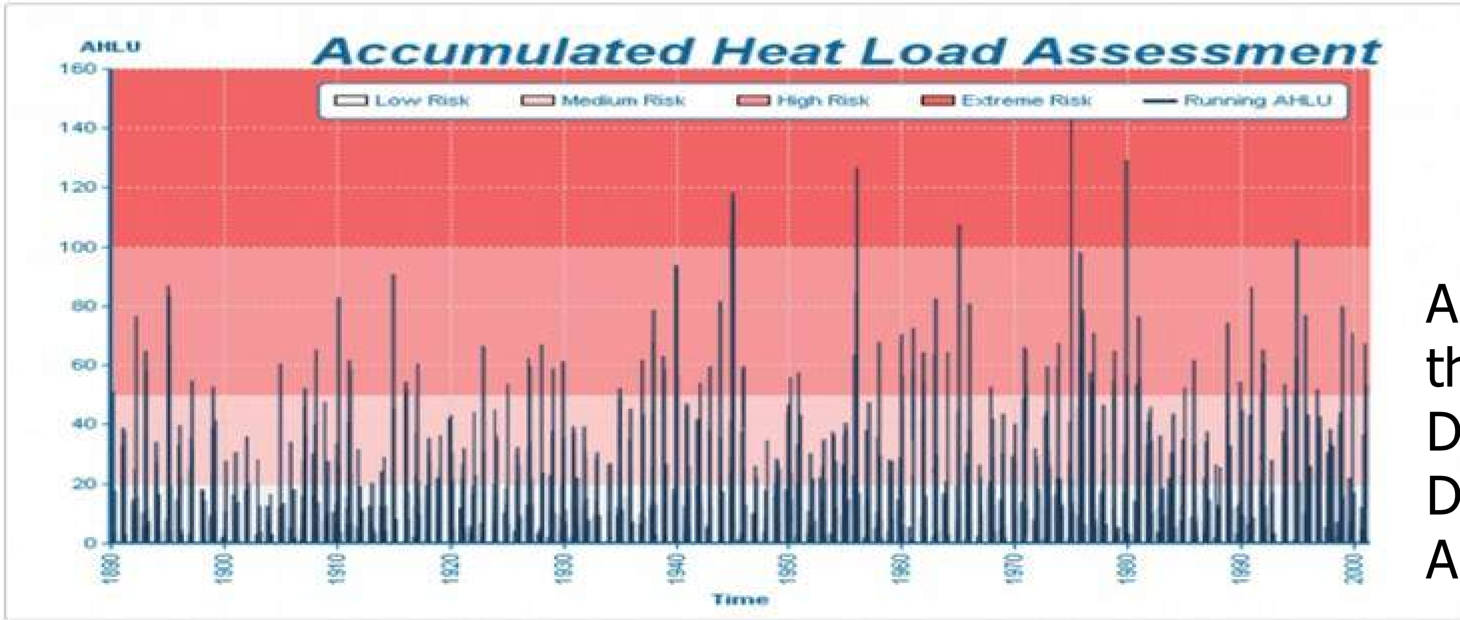


Northern wet season (October–April) rainfall deciles for the last 20 years (1998–99 to 2017–18). A decile map shows where rainfall is above average, average or below average for the recent period, in comparison with the entire national rainfall record from 1900.



Number of days each year where the Australian area-averaged daily mean temperature is extreme. Extreme days are those above the 99th percentile of each month from the years 1910–2017. These extreme daily events typically occur over a large area, with generally more than 40 per cent of Australia experiencing temperatures in the warmest 10 per cent for that month.

20th Century Reanalysis has provided improved long-term assessment of the return periods and trends of the Accumulated Heat Load Index



ALHI for the Darling Downs, Australia

- **Utilising the 20th Century Reanalysis Process, results show that in the *Darling Downs region* the AHLI has reached extreme risk levels on six occasions in 100 years – and the number of high or extreme values appears to be increasing.**

- The ALHI also used to calculate recovery times from excessive heat load (EHL). (The best recovery from heat load occurs when the HLI below 74 between four to six hours during the night. - longer periods needed if exposure to EHL has been prolonged).

Farm Management Decisions and Climate Systems operating at various time scales (Stone and Meinke, 2005).

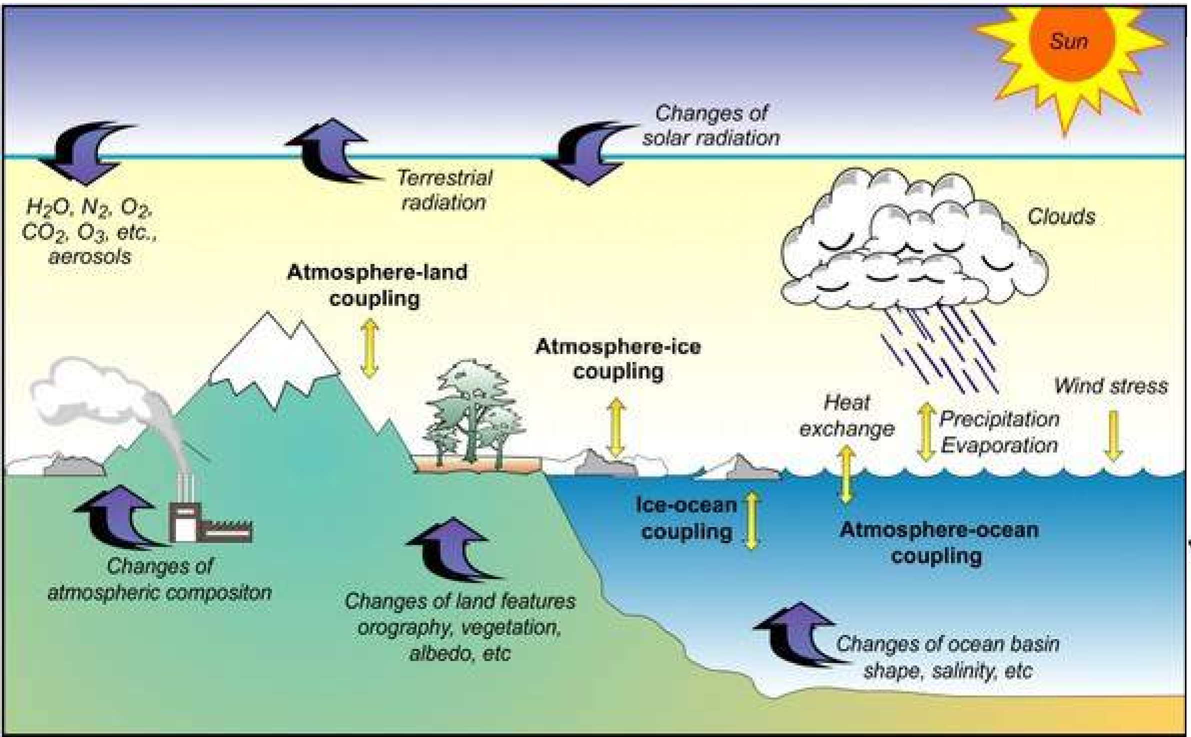
Decision type (eg. only)	Climate period
Logistics (scheduling of planting/harvest operations; **short-term buying decisions**	Intraseasonal (>0.2) **MJO**
Tactical management (fertiliser/pesticide use)	Intraseasonal (0.2-0.5)
Crop type/area/fertiliser app; **stocking rates**; **agistment planning**; grain supply.	Seasonal (~1.0) **El Nino/La Nina (ENSO)**
Crop sequence; **agistment**	Interannual (1-2.0)
Crop rotation (eg. winter or summer crop); selling due to likely drought in QBO West Phase +STR	Annual/biennial (2) **QBO**
Industry issues(eg. grain/cotton); land purchase	Decadal (~10) +**STR**
Agricultural industry (eg. crops or pasture)	Interdecadal (10-20) IPO
Landuse (eg. Agriculture or natural system)	Multidecadal (20+)
Landuse and adaptation of current systems	**Climate change**

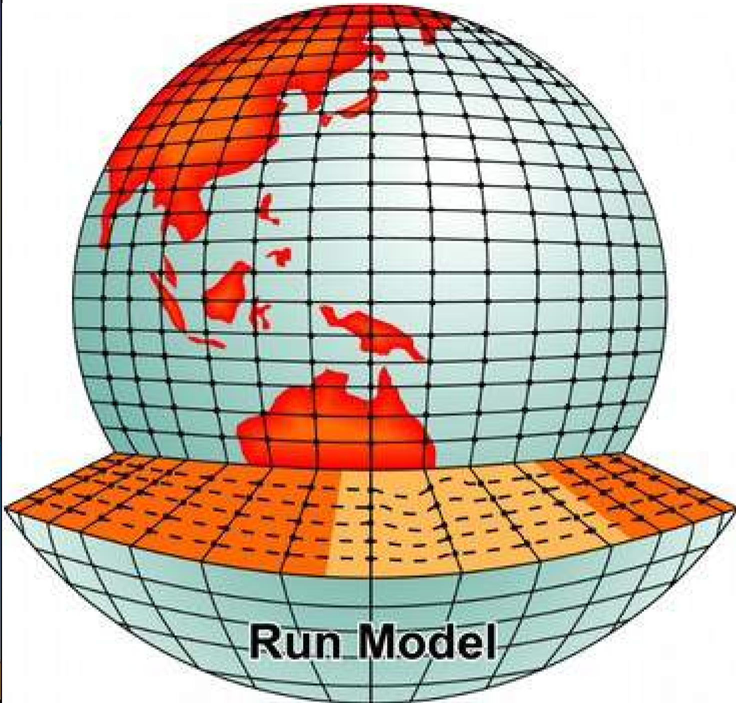
General Circulation Model (GCM) features

Four main components: the atmosphere, the land surface and biosphere, the oceans and polar ice

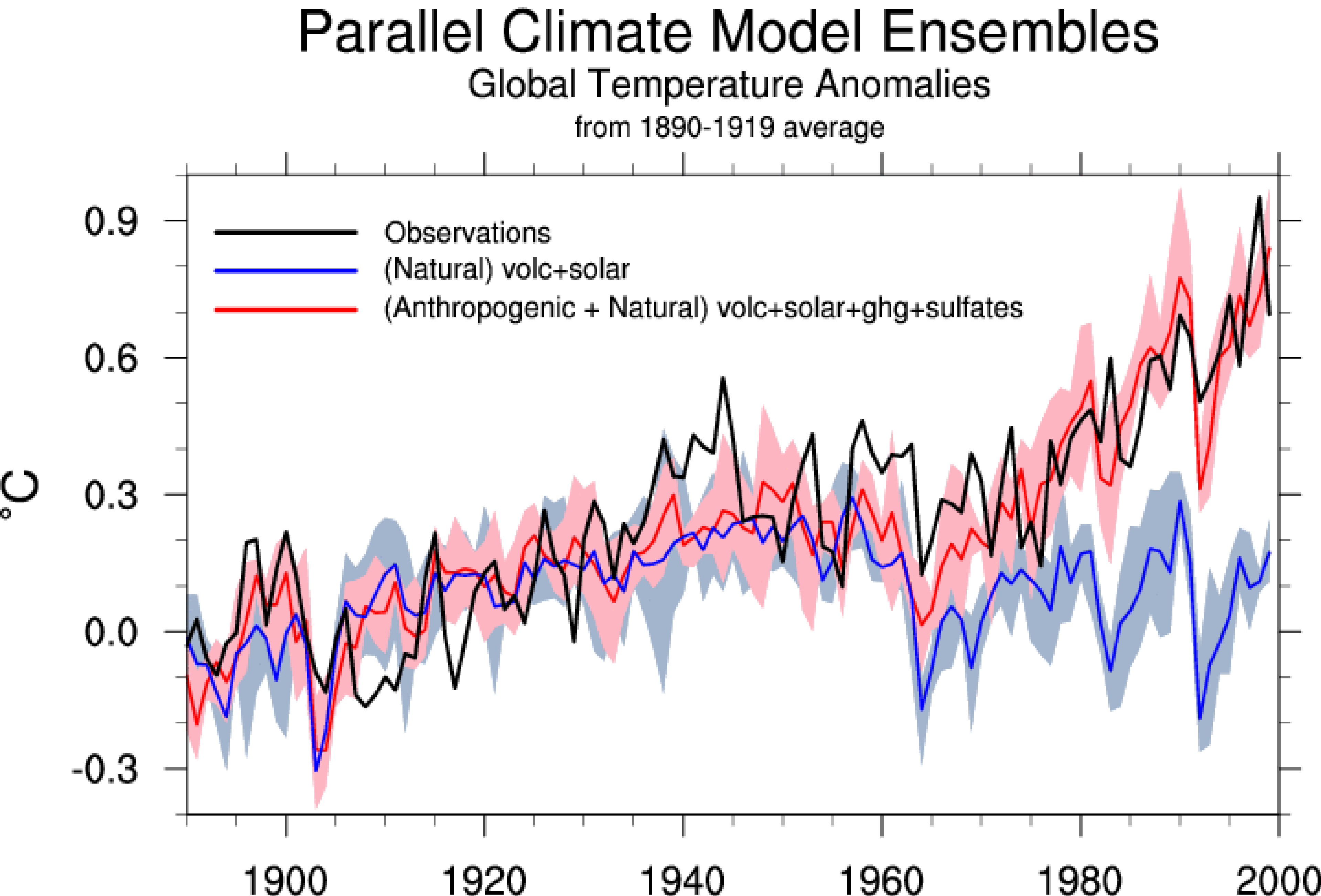
Data are computed in 30-minute time-steps over a global grid for a series of months or years: Models adequately simulate observed daily weather and average climate patterns

The model horizontal resolution (as used in GloSea5) is N216 (0.8° in latitude and 0.5° in longitude): ~50 km in mid-latitudes: 85 levels in the vertical for the atmosphere and 75 levels in the vertical for the ocean.

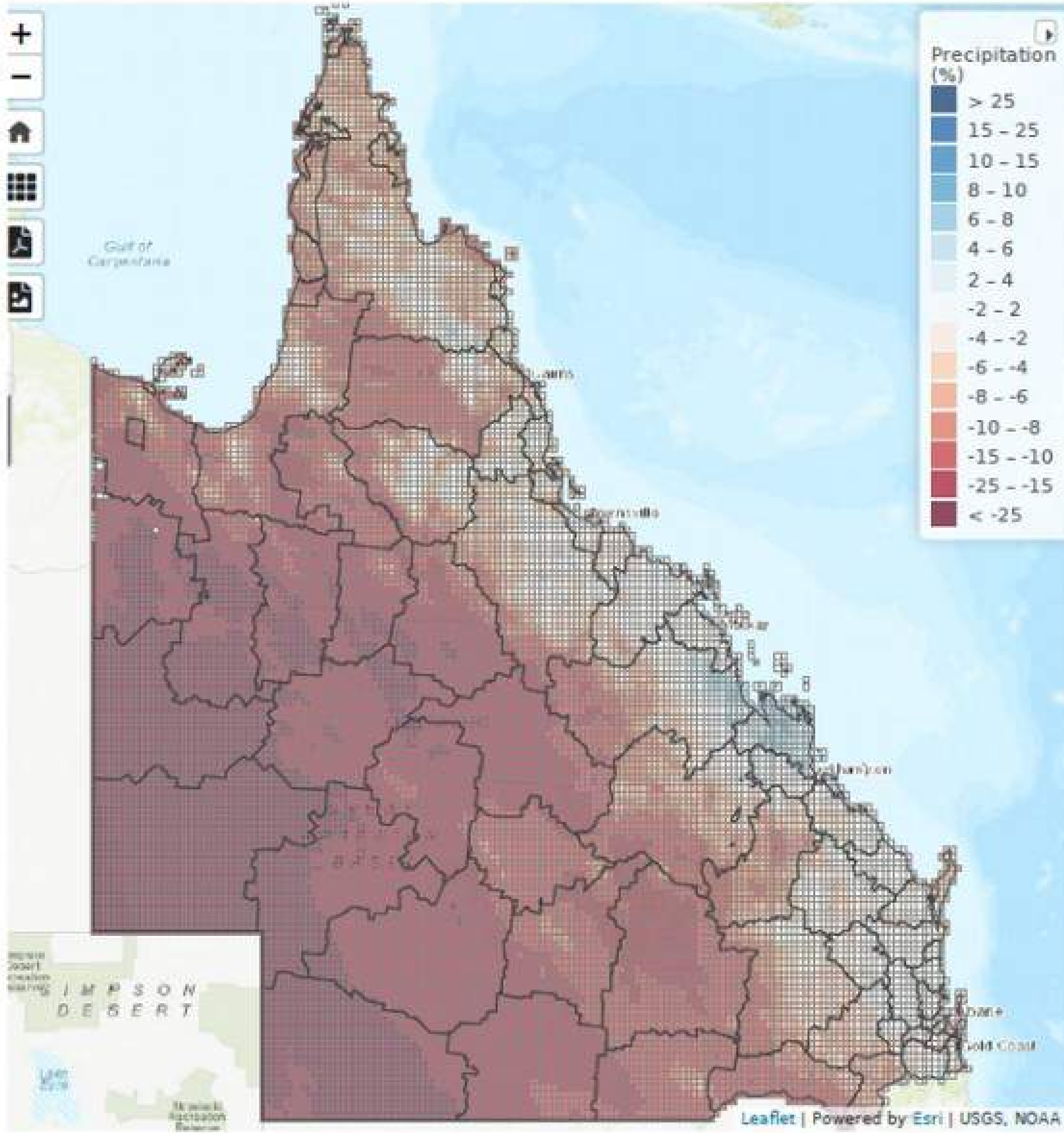




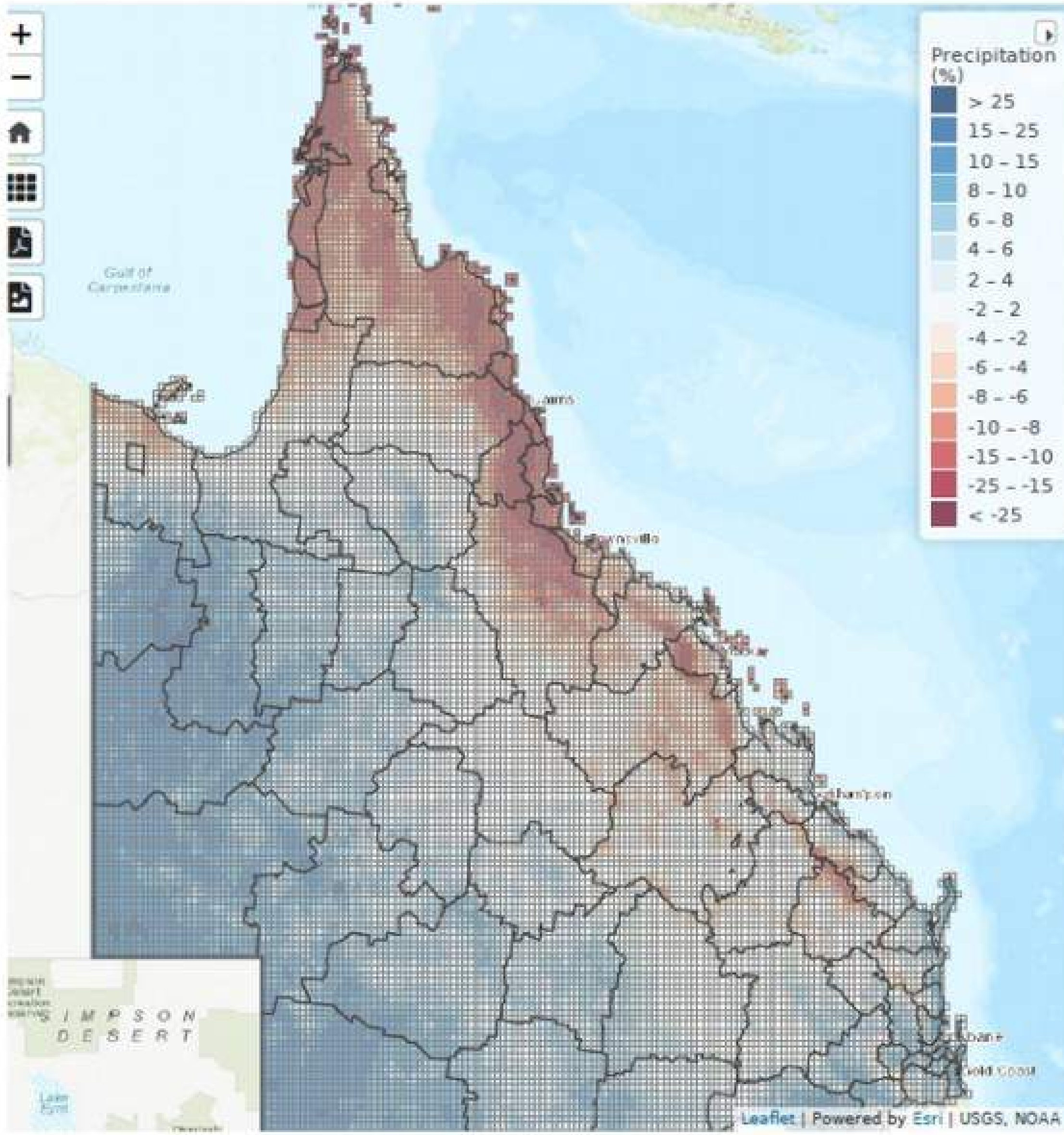
Moving forward: ocean-atmosphere climate models



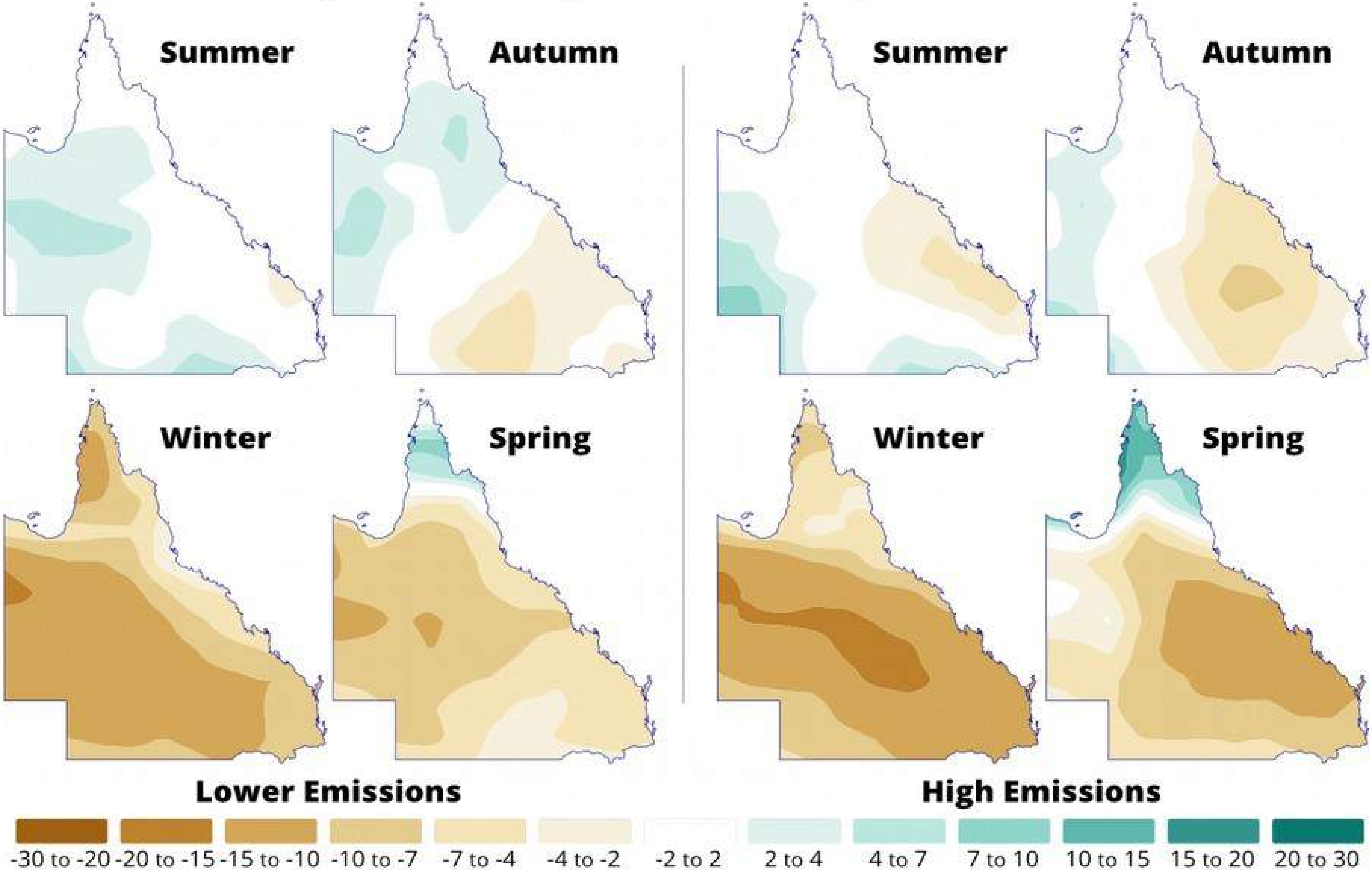
Queensland winter precip. Projections 2050



Queensland summer precip. Projections 2050

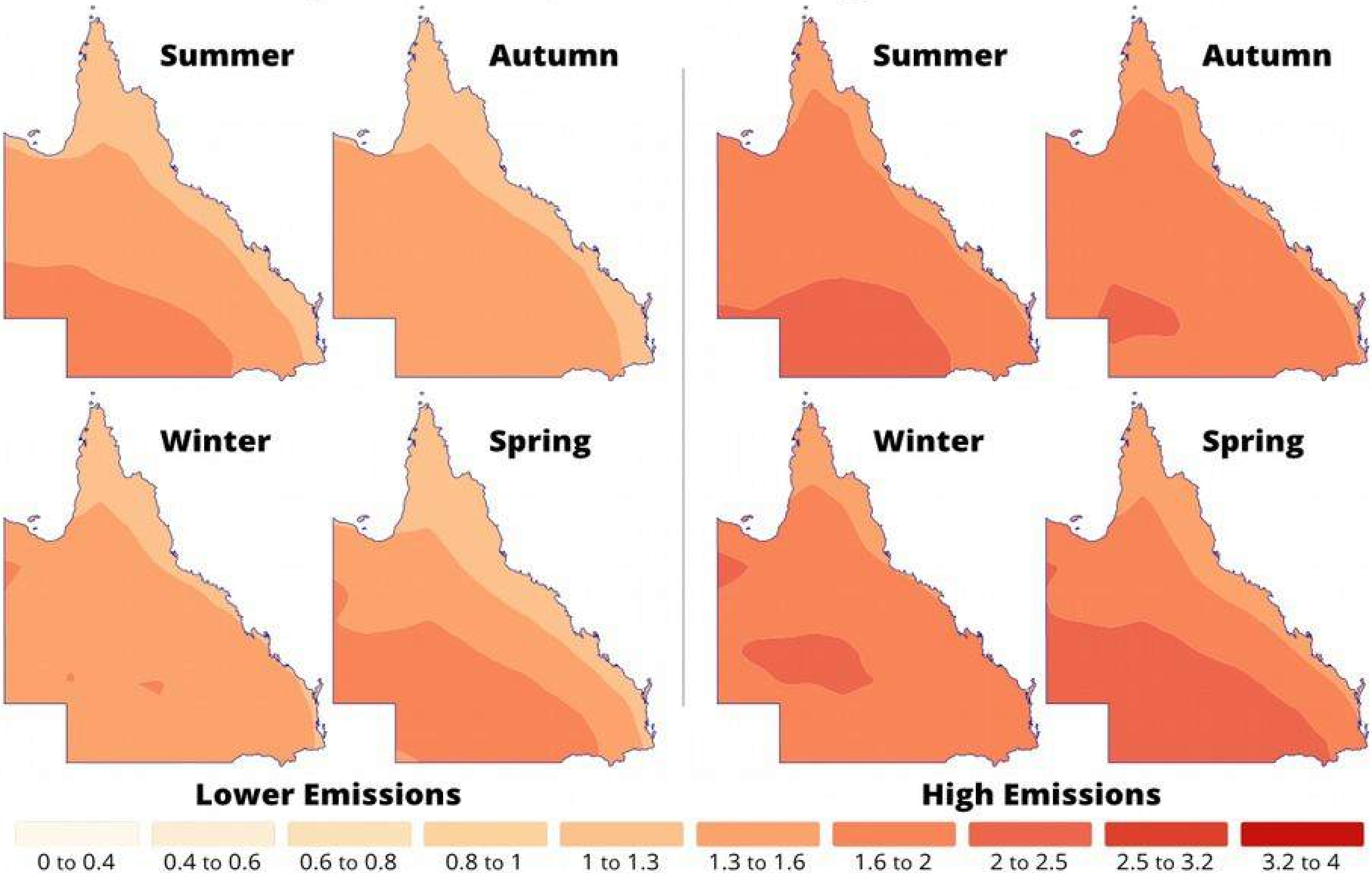


Projected Precipitation Change (%) at 2050



https://www.longpaddock.qld.gov.au/qld-future-climate/

Projected Temperature Change (°C) at 2050



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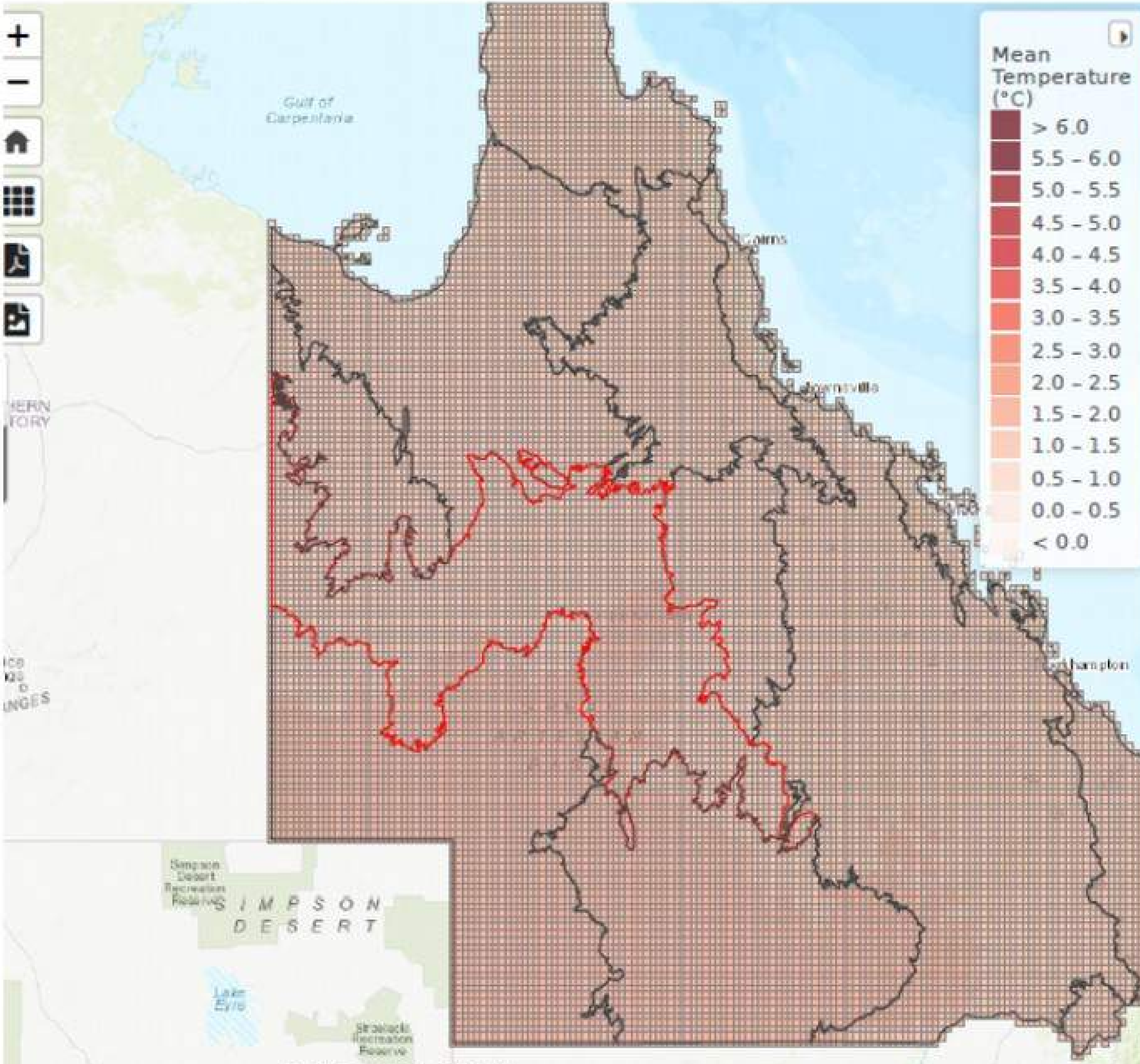
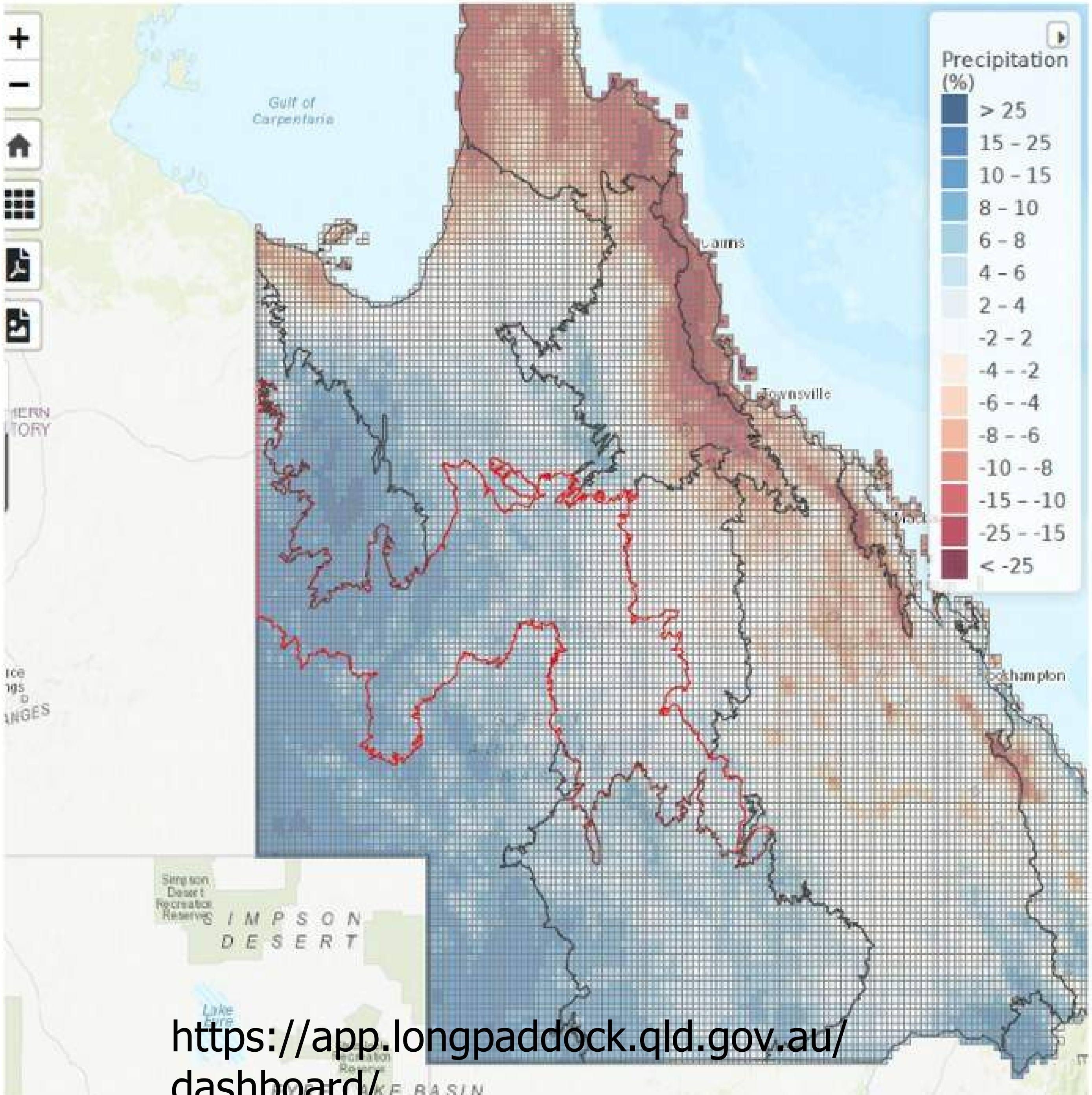
Summer temperature projections for 2050 by bioregions (Mitchell Grasslands highlighted)



https://app.longpaddock.qld.gov.au/dashboard/

Summer rainfall projections for 2050 by bioregions (Mitchell Grasslands highlighted)



https://app.longpaddock.qld.gov.au/dashboard/

Table 5. Present (1964-2003) and projected number of days above 35°C at 20 Australian locations. Low (L) and high (H) scenarios are based on data shown in Fig. 14. All values are rounded to the nearest integer.

City	*Present*	*2020*		*2030*		*2040*		*2050*		*2060*		*2070*		*2080*	
		L	*H*	*L*	*H*	*L*	*H*	*L*	*H*	*L*	*H*	*L*	*H*	*L*	*H*
Adelaide	17	18	23	19	25	19	29	20	32	21	39	22	46	22	53
Alice Springs	89	94	114	96	125	99	129	101	153	104	173	106	191	108	207
Brisbane	1	1	2	1	3	1	4	1	7	2	13	2	26	2	42
Broome	54	61	90	64	119	69	163	72	208	80	258	84	293	87	316
Cairns	3	4	7	4	9	4	19	5	34	5	74	5	119	5	159
Canberra	5	6	9	6	12	6	15	7	19	7	27	8	35	8	45
Charleville	65	70	91	72	105	75	108	77	135	80	157	82	177	83	195
Cobar	41	44	57	45	65	47	68	48	92	50	111	51	127	52	144
Coffs Harbour	2	2	2	2	2	2	3	2	4	2	7	2	11	2	16
Darwin	11	15	46	18	73	20	123	23	177	27	256	31	305	31	332
Halls Creek	156	164	189	166	205	172	218	175	241	179	268	182	290	185	307
Kalumburu	140	153	197	158	230	167	262	171	291	178	320	185	337	187	346
Launceston	0	0	0	0	0	0	1	0	1	0	2	0	3	0	4
Longreach	115	121	147	123	163	129	164	131	199	134	222	136	239	139	256
Melbourne	10	10	13	10	15	11	17	11	21	11	26	12	31	12	36
Mildura	33	35	42	35	47	37	53	38	61	39	74	40	85	40	98
Perth	27	28	35	29	38	30	43	31	48	32	58	33	68	33	79
Sydney	3	4	5	4	6	4	7	4	9	4	13	4	18	4	26
Townsville	4	5	8	5	12	5	21	6	36	6	77	7	127	7	164
Woomera	51	54	64	56	70	58	78	59	88	60	104	62	120	63	135

Major increases in the projected number of days above 35C at key Australian locations (using the approach of Suppiah et al (2007; 2010)

International Climate Initiative 2016

The "De-Risk" project

The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)

"Applying seasonal climate forecasting and innovative insurance solutions to climate risk management in the agriculture sector in SE Asia"

Submitted by:
The World Meteorological Organisation, Geneva.
Implementing partners:

- The University of Southern Queensland (USQ), Australia - subcontracting to Willis Towers Watson Ltd.
- International Center for Tropical Agriculture (CIAT), Vietnam.

The ability to seasonally forecast extremely high levels of <u>Minimum Temperatures</u> for the ensuing season/three months:

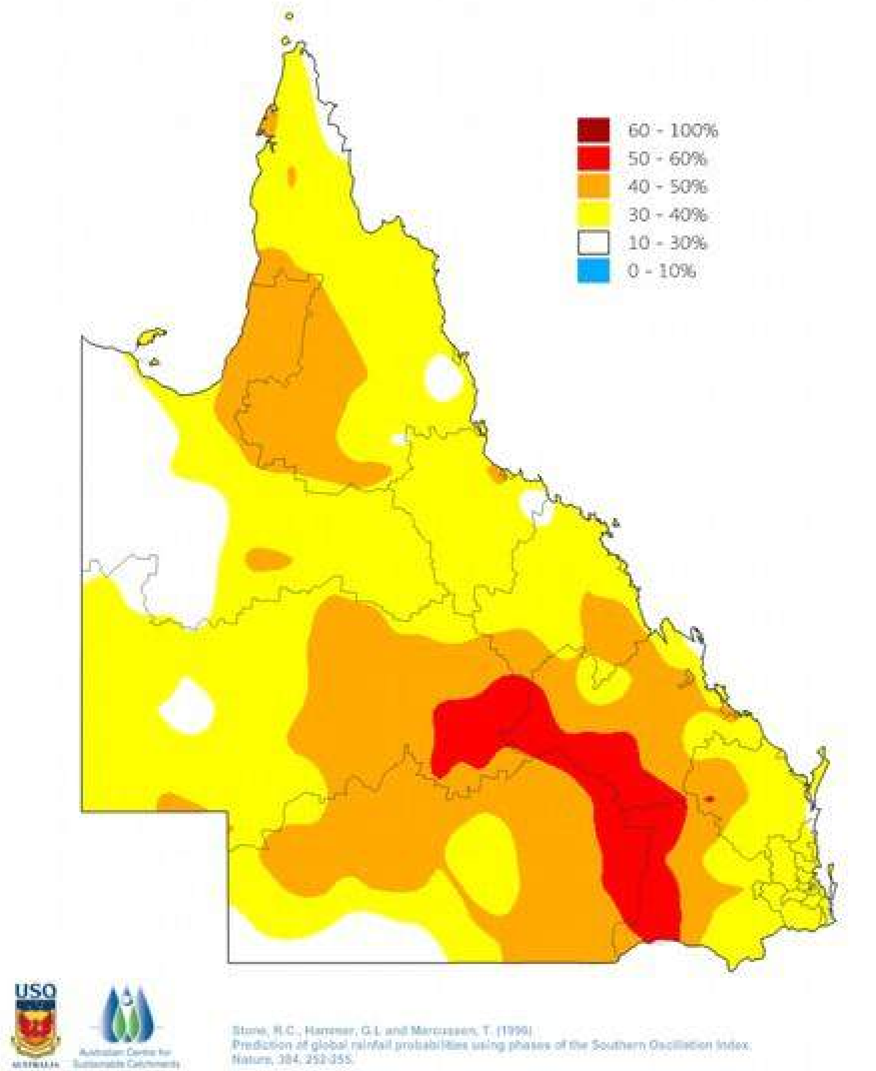
Example: describing the risk of Minimum Temp being in the highest 20% of possible values for the core summer period following earlier onset of an El Niño period (Stone and Marcussen, 2012).

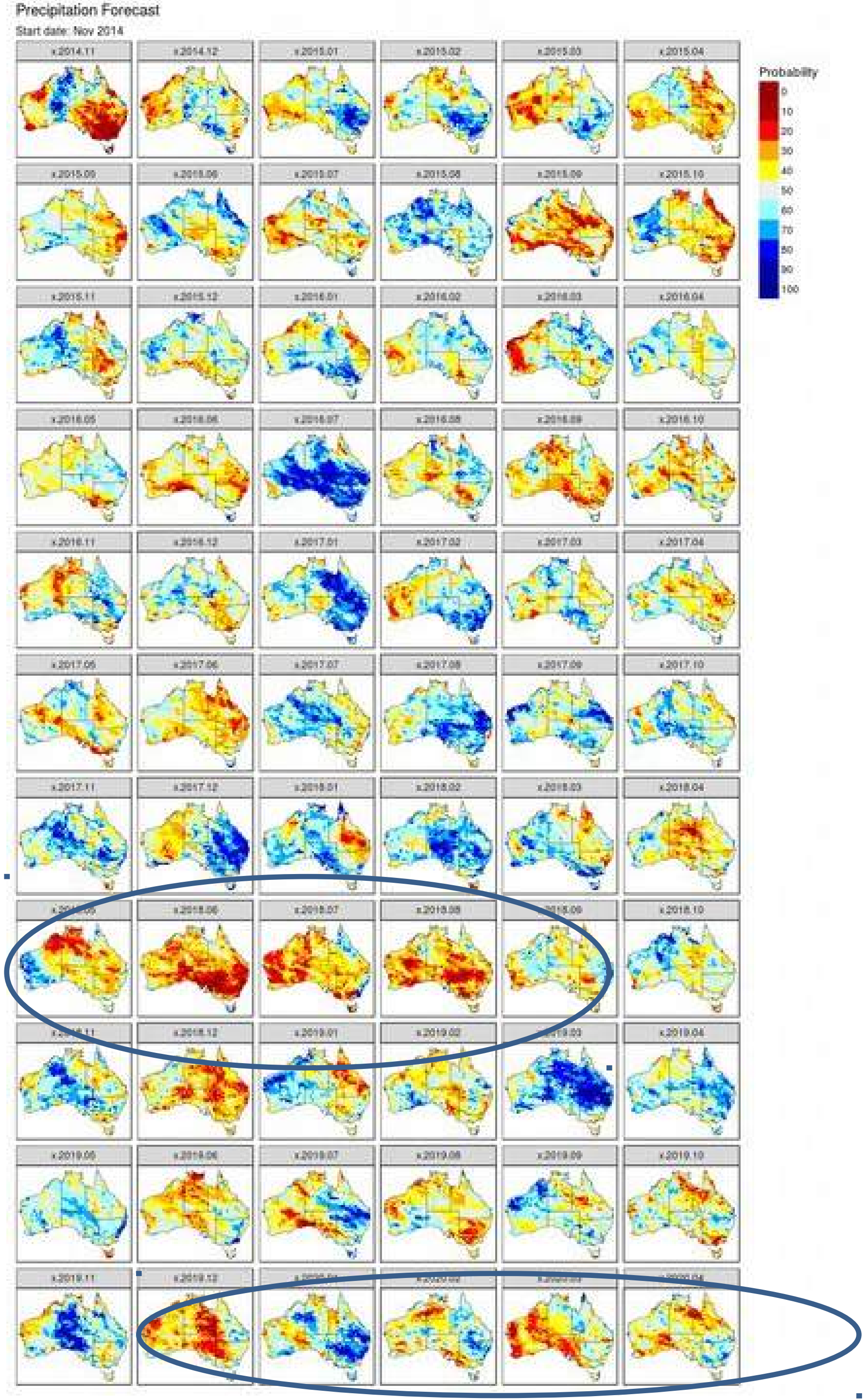
In this example, note the regions shaded dark orange / red which have greatly increased risk of excessive maximum temperatures with this pattern.

Probability of Being in
the Highest 20% of Minimum Temperatures

January / March

Based on Consistently Negative phase
during November / December





Multi-year (5 year) monthly forecast outputs developed in conjunction with UK MetOffice

“We show, among other things, that markedly reducing global greenhouse gas emissions reduces the rate at which we will experience unprecedented high monthly temperatures.

However, these benefits take more than twenty years to be significant, and the likelihood of setting unprecedented high temperature records is projected to remain at high levels for the next two decades - or much longer unless large emission reductions occur.

This means that people will need to manage risks associated with the frequent occurrence of what will be unprecedented high monthly temperatures, for at least the next twenty years” (Scott Power, *Nature*, 2019).

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Likely future Impacts:

Increase in variability – lower rainfall in drought years – higher falls in wet years, especially in NW rangelands and the Gulf region.

Higher temperatures overall and in numbers of extreme heat days (and nights/feedlot issues).

Most climate change projections suggest major fall in winter/spring rainfall (in Queensland and eastern Australia) but varying impact on summer/autumn rainfall – increase in some regions.

Value in using seasonal and, potentially, decadal forecasting to assist with year-to-year management decisions as an incremental approach..

If GHGs were stopped now (especially globally rather than locally) then we still have 20 years of these conditions to manage before climatic conditions start return to more 'normal'..

Pasture Degradation and Recovery in Australia's Rangelands

Learning from History

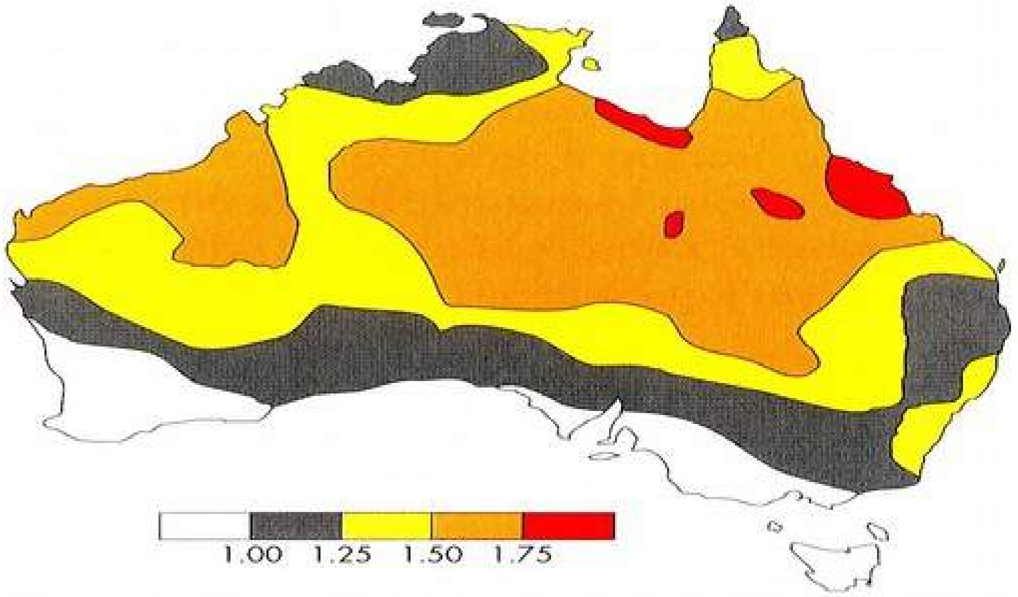
Edited by
Greg McKeon, Wayne Hall, Beverley Henry, Grant Stone and Ian Watson

Thank you


CANADA
NORTH AMERICA
UNITED STATES
MEXICO
Tropic of Cancer
MARSHALL ISLANDS
KIRIBATI
equator
International
PACIFIC OCEAN
COOK ISLANDS (NZ)
FRENCH POLYNESIA (FR)
Tropic of Capricorn
AUSTRALIA
Antarctic Circle

– Key points: Australia has the world's highest levels of year-to-year rainfall variability **especially in Queensland.**

Map 1: **Rainfall variability relative to other world locations with the same annual rainfall**



Source: Nicholls, Drosdowsky and Lavery, Bureau of Meteorology Research Centre, from a paper 'Australian rainfall variability and change', yet to be published.

Map 2: **Correlation between annual rain and an[ ] 1995**

Result 1: Use of the *Accumulated* Heat Load Index or Unit (AHLI/AHLU) incorporating "Reanalysis Data"

- Cattle response to heatwaves best described by an "Accumulated Heat Load Index", determined by the *duration of exposure* above a threshold heat load index.

- The AHLI/ALHU calculates a single index value based on empirical weightings of input variables and predicts thermal stress will occur once a certain threshold value of the index is exceeded.

- An AHLI value: 0-20 = low risk; 20-50 = medium risk; 50-100 =high risk; > 100 = extreme risk for cattle.

- Key now is to determine return frequency of such extreme periods - **in this project utilisation of the "20th Century Reanalysis System" is applied**.

Value in more targeted approaches – using downscaling – example for the Lower Balonne using five 'core' General Circulation Models.

Likely rainfall shifts for recording stations in the Lower Balonne as provided in five core GCMs

January: as an example for rainfall for the Balonne River at St George:

- GFCM2.1 depicts a 12% increase (compared to the 1971-2000 mean) most likely in January,
- GFCM2.0 depicts a 41% increase rainfall in January,
- HADGEM depicts a 9% increase in rainfall,
- MPEH5 depicts a 7% increase in rainfall and
- NCCCSM depicts a (modest) 1% decrease in rainfall.

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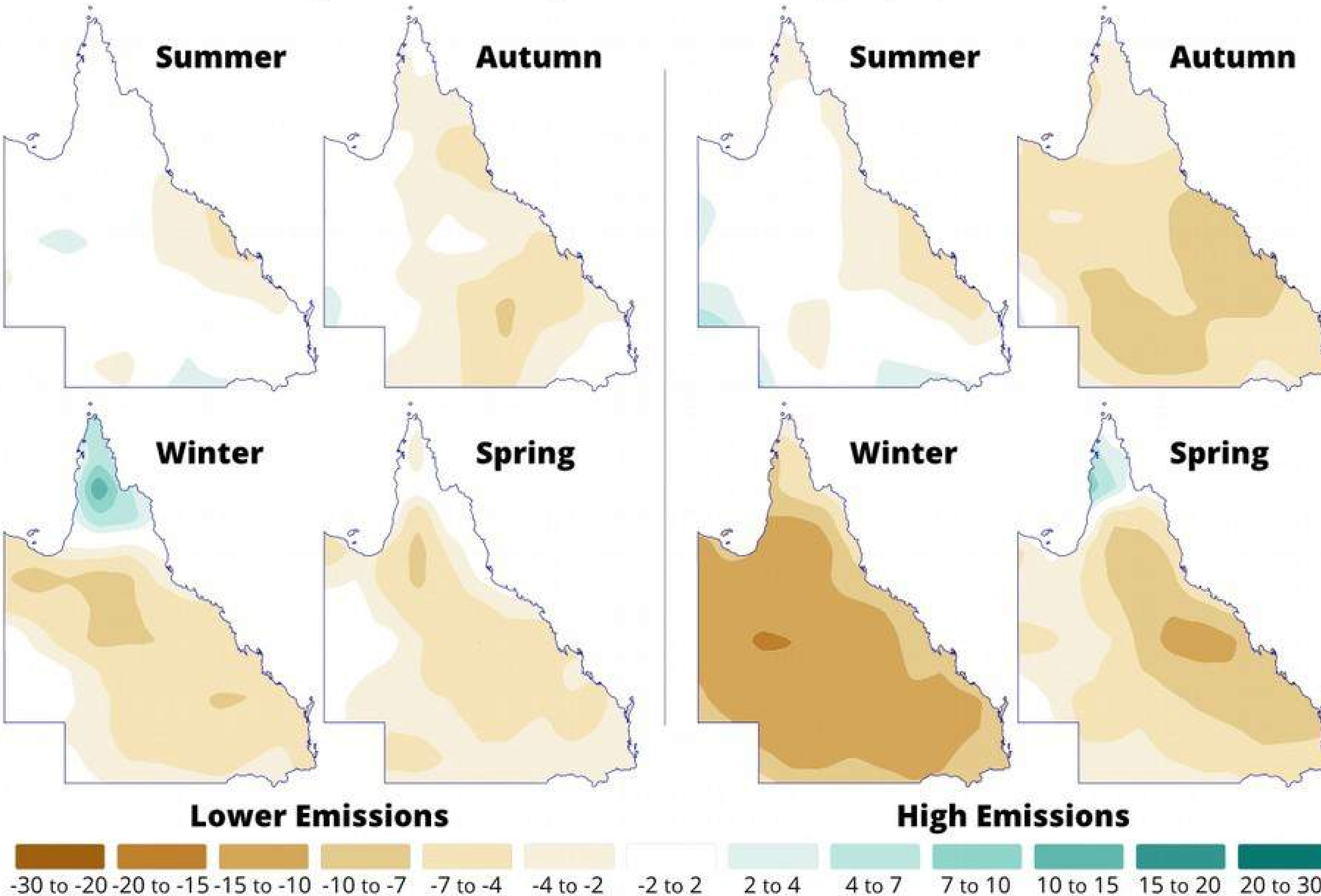
Projected Precipitation Change (%) at 2030



The Queensland Drought Mitigation Centre –

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Director, Centre for Applied Climate Sciences; Queensland Drought Mitigation Centre University of Southern Queensland, Australia.

President, Commission for Agricultural Meteorology, World Meteorological Organisation, Geneva.

Queensland Government

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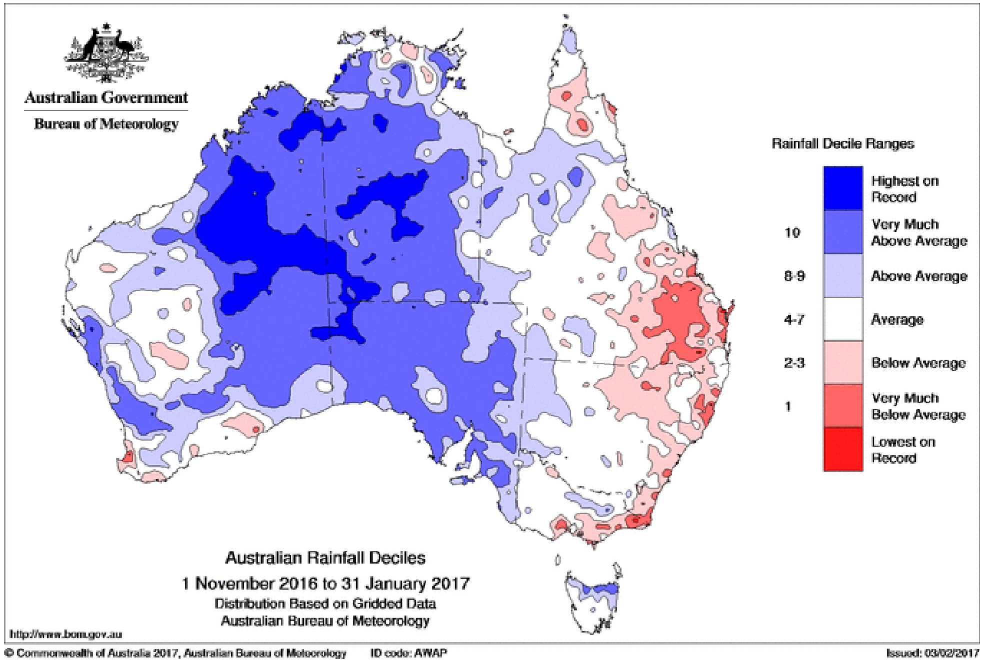
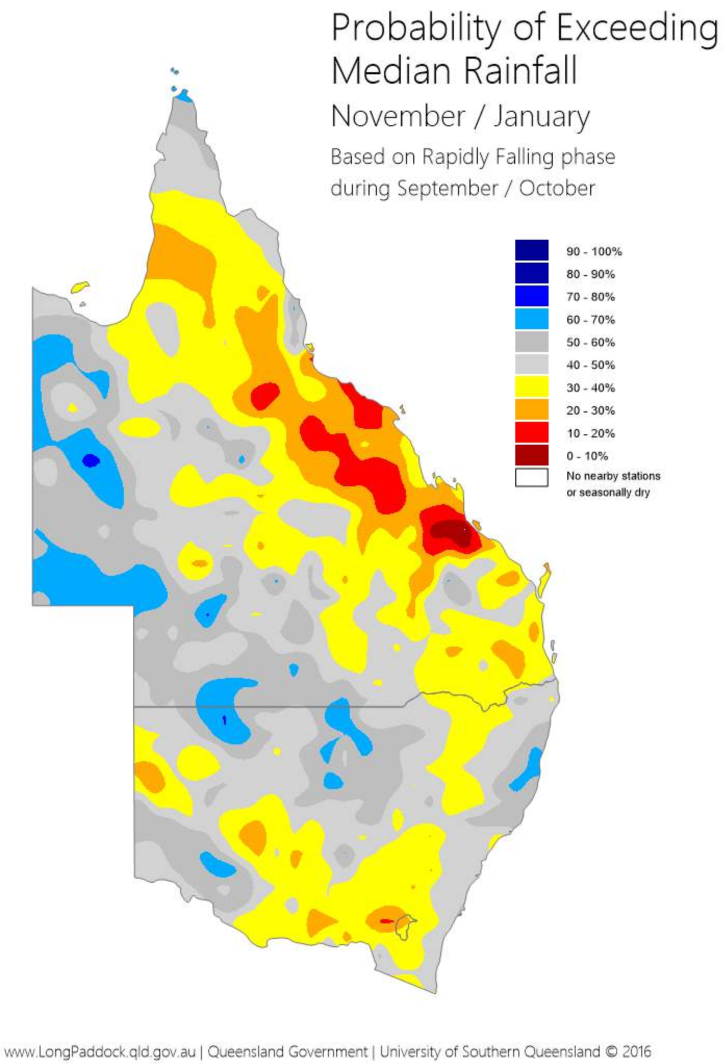




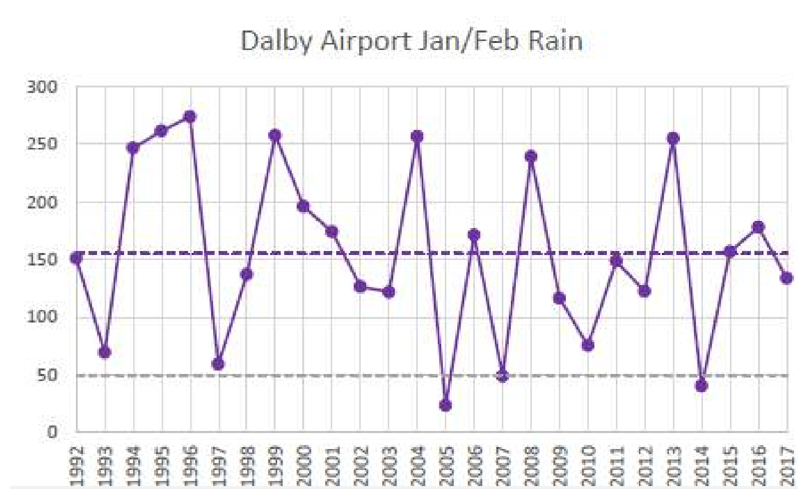
Actual rainfall (between Nov 2016 and Jan 2017) and seasonal climate forecast rainfall (right): a recent forecast

Drought insurance tool example

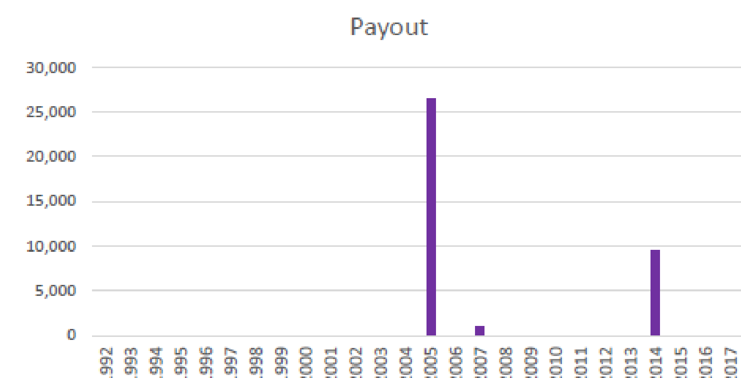
1. Enter strike and limits

Inputs	
Attachment Strike	50
Limit Strike	0
Tick Value (AUD)	1,000

2. Assess when low seasonal rainfall occurs



3. Calculate payouts for when low seasonal rainfall occurs



•Image from: https://www.linkedin.com/pulse/collaborating-improve-drought-tolerance-crops-amarjit-s-basra

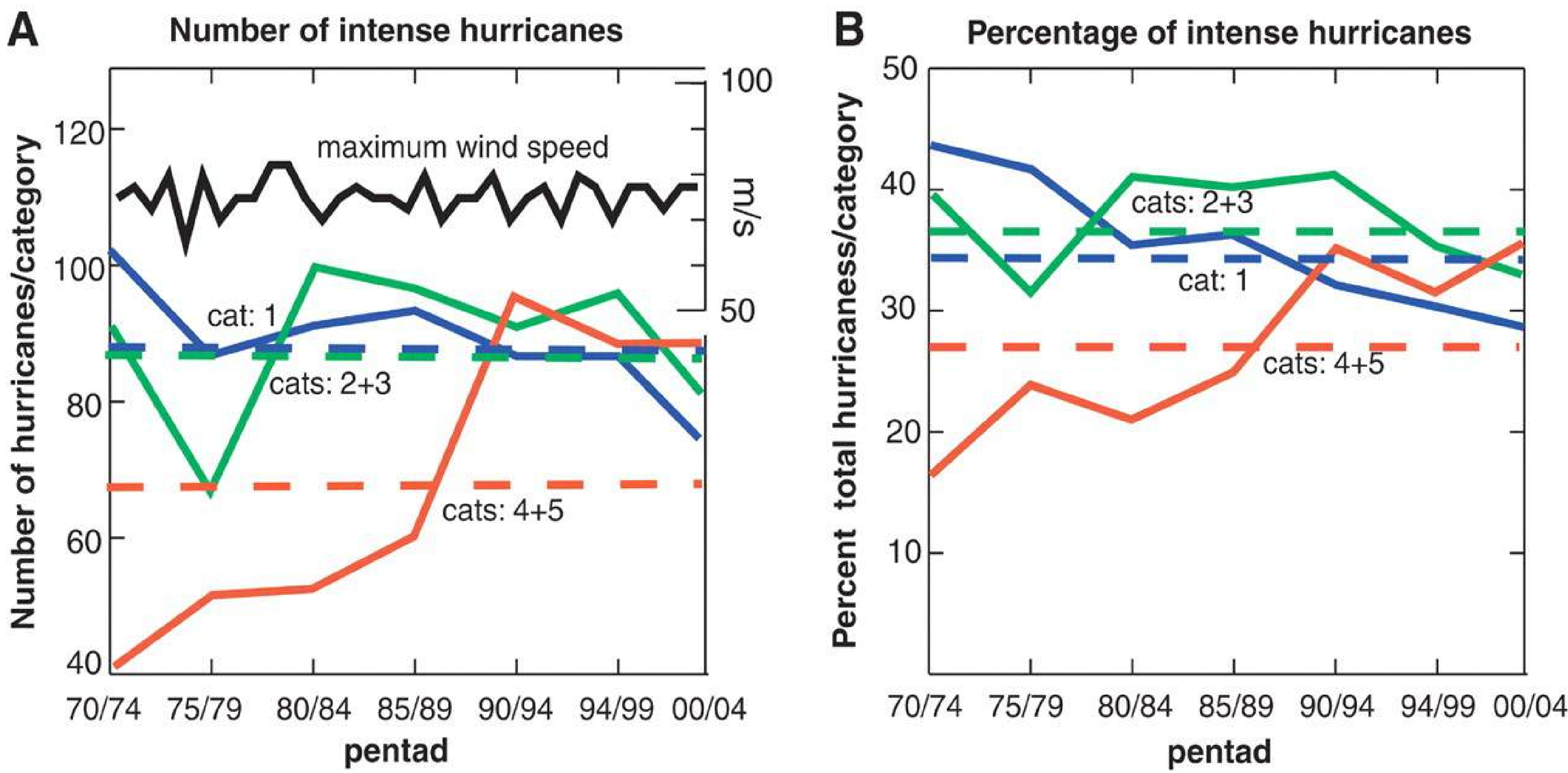
Crop losses from low seasonal rainfall

Ratio of maximum annual flow to minimum annual flow for selected rivers (Douglas, 2010).

COUNTRY	RIVER	RATIO BETWEEN THE MAXIMUM and the MINIMUM ANNUAL FLOWS
BRAZIL	AMAZON	1.3
SWITZERLAND	RHINE	1.9
CHINA	YANGTZE	2.0
SUDAN	WHITE NILE	2.4
USA	POTOMAC	3.9
SOUTH AFRICA	ORANGE	16.9
AUSTRALIA	MURRAY	15.5
AUSTRALIA	HUNTER	54.3
AUSTRALIA	DARLING	4705.2

Intensity of hurricanes according to the Saffir-Simpson scale (categories 1 to 5):

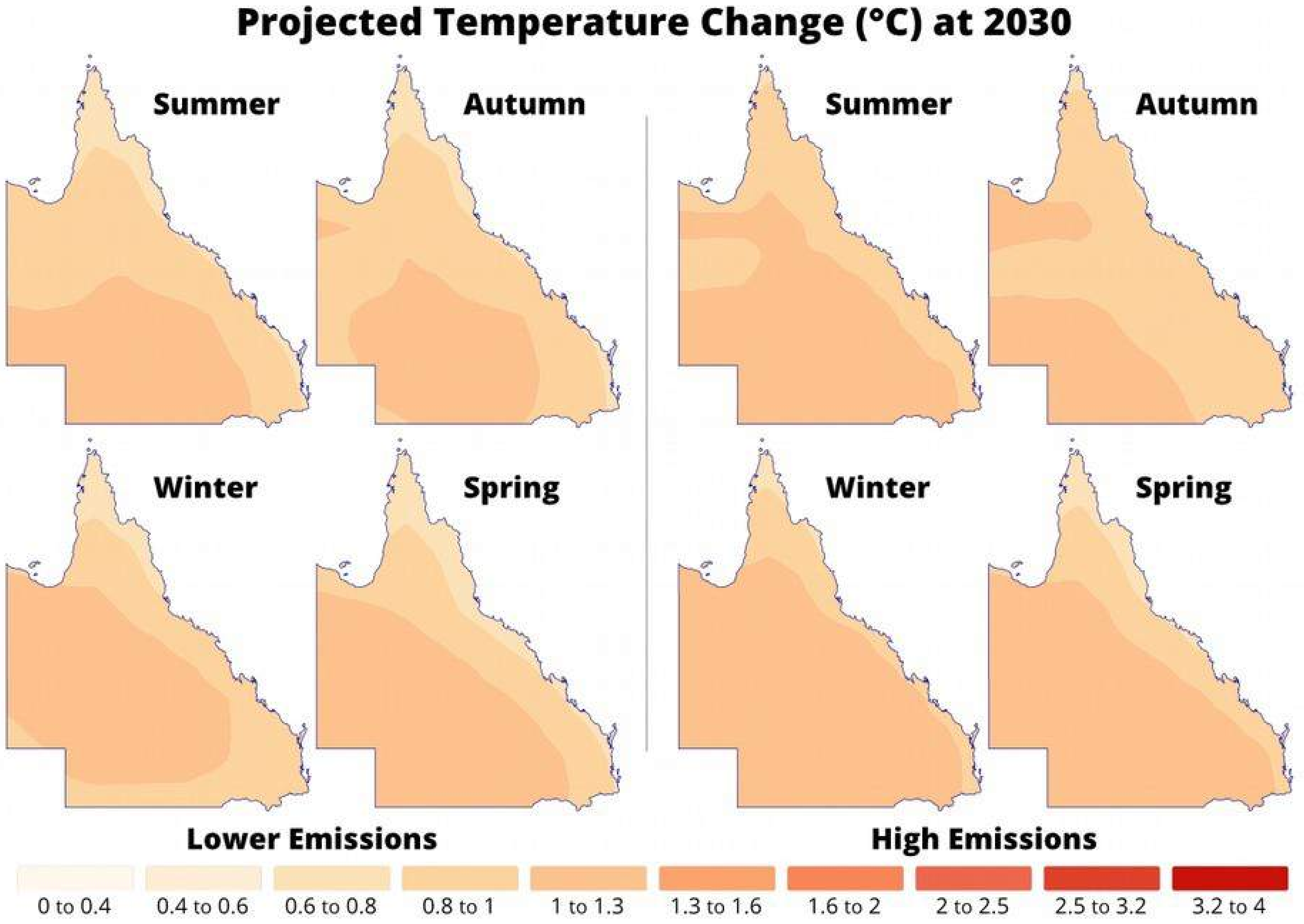
100% increase in Category 5 and Category 4 systems since 1970.



P. J. Webster et al., Science 309, 1844 -1846 (2005)

Science AAAS

‘Based on a range of models, it is likely that future tropical cyclones will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing increases in tropical SSTs’


Projected Temperature Change (°C) at 2030
Summer
Autumn
Winter
Spring
Summer
Autumn
Winter
Spring
Lower Emissions
High Emissions
0 to 0.4
0.4 to 0.6
0.6 to 0.8
0.8 to 1
1 to 1.3
1.3 to 1.6
1.6 to 2
2 to 2.5
2.5 to 3.2
3.2 to 4