

Forewarned is Forearmed – New extremes outlooks for Agriculture

Dr. Andrew Watkins, Avijeet Ramchurn, Dale Grey

FWFA Webinar | 8 November 2021

BUREAU OF METEOROLOGY



**CLIMATE
OUTLOOKS**
now forecasting
climate extremes



Australian Government
Bureau of Meteorology

AGRICULTURE VICTORIA

Forewarned is Forearmed (FWFA) 2017-2022



Forecasting "extreme" climate events on multi-week and seasonal timescales

Research partners

BoM
Univ. Melbourne
Monash Univ.
Univ. S. Queensland
SARDI
Agriculture Victoria
DAFQ
Birchip Cropping Group

Users



Rural RDC partners

Meat and Livestock Australia
Grains RDC
Sugar Research Australia
Cotton RDC
AgriFutures Australia
Dairy Australia
Wine Australia
Australian Pork



Australian Government
Bureau of Meteorology

<http://www.bom.gov.au/research/projects/FWFA/>



 Australian Government
Department of the Environment
and Energy

Forewarned is forearmed: managing the impacts of extreme climate events

User Needs Synthesis Report

Page 12 of 166

A photograph of a brown cow standing in a grassy field. The cow is facing slightly to the right but looking towards the camera. The background shows a line of trees and a clear sky.[illegible]

The Very Fast Break

Very Fast Break
3 November 2017

Jale Grey
Seasonal Risk Agronomist
Bendigo

AGRICULTURE VICTORIA



Underpinning science and increased understanding

BAMS
Article

The 2019 Southern Hemisphere Stratospheric Polar Vortex Weakening and Its Impacts

Eun-Pa Lim, Harry H. Hendon, Amy H. Butler, David W. J. Thompson, Zachary D. Lawrence, Adam A. Scaife, Theodore G. Shepherd, Inna Politichouk, Hisashi Nakamura, Chiaki Kobayashi, Ruth Comer, Lawrence Coy, Andrew Dowdy, Rene D. Garreaud, Paul A. Newman, and Guomin Wang

nature geoscience ARTICLES
<https://doi.org/10.1038/s41561-019-0456-x>

Australian hot and dry extremes induced by weakenings of the stratospheric polar vortex

Eun-Pa Lim^{1*}, Harry H. Hendon¹, Ghyslaine Boschat^{2,3}, Debra Hudson¹, David W. J. Thompson⁴, Andrew J. Dowdy¹ and Julie M. Arblaster^{2,3,5}

scientific reports

Why Australia was not wet during spring 2020 despite La Niña

Eun-Pa Lim^{1,2}, Debra Hudson¹, Matthew C. Wheeler³, Andrew G. Marshall⁴, Andrew King², Hongyan Zhu⁵, Harry H. Hendon^{1,3}, Catherine de Burgh-Day¹, Blair Trewin¹, Morwenna Griffiths¹, Avijeet Ramchurn³ & Griffith Young¹

JGR Atmospheres

RESEARCH ARTICLE
10.1029/2020JD032952

Key Points:

- Extreme heat developed over Australia in October 2020 following the sudden stratospheric warming in September 2020.
- Forecasts initialized on 1 August captured the early breakdown of the

Impact of Interannual Ozone Variations on the Downward Coupling of the 2002 Southern Hemisphere Stratospheric Warming

H. H. Hendon¹, E.-P. Lim¹, and S. Abhik¹

¹Bureau of Meteorology, Melbourne, Victoria, Australia

Climate Dynamics
<https://doi.org/10.1007/s00382-020-05432-x>

Impacts of the Madden–Julian Oscillation on wintertime Australian minimum temperatures and Southern Hemisphere circulation

Guomin Wang¹ · Harry H. Hendon¹

Received: 27 December 2019 / Accepted: 18 August 2020
© Springer-Verlag GmbH Germany, part of Springer Nature 2020

CSIRO PUBLISHING

Journal of Southern Hemisphere Earth Systems Science
<https://doi.org/10.1007/s12017-021-00011-1>

Influence of the Madden-Julian Oscillation on multiweek prediction of Australian rainfall extremes using the ACCESS-S1 prediction system

Andrew G. Marshall^{1a,c}, Harry H. Hendon^{1b} and Debra Hudson^{1b}

^aBureau of Meteorology, Hobart, Tas. 7000, Australia.

^bBureau of Meteorology, Docklands, Vic., Australia.

^cCorresponding author. Email: andrew.marshall@bom.gov.au

 Australian Government
Bureau of Meteorology

A hybrid parametrisation for precipitation probability of exceedance data

Catherine de Burgh-Day, Francis Dillon

July 2021

Received: 26 August 2019 | Revised: 10 March 2020 | Accepted: 12 March 2020 | Published online: 13 April 2020
DOI: 10.1002/qj.3789

RESEARCH ARTICLE

Sub-seasonal to seasonal prediction of rainfall extremes in Australia

Andrew D. King¹ | Debra Hudson² | Eun-Pa Lim² | Andrew G. Marshall³ | Harry H. Hendon² | Todd P. Lane¹ | Oscar Alves²

Quarterly Journal of the
Royal Meteorological Society

Climate Dynamics
<https://doi.org/10.1007/s00382-021-05661-8>

Tropical forcing of Australian extreme low minimum temperatures in September 2019

Eun-Pa Lim¹ · Harry H. Hendon¹ · Li Shi¹ · Catherine de Burgh-Day¹ · Debra Hudson¹ · Andrew King² · Blair Trewin¹ · Morwenna Griffiths¹ · Andrew Marshall¹

Received: 13 July 2020 / Accepted: 17 January 2021
© Crown 2021

Australian hot and dry extremes induced by weakenings of the stratospheric polar vortex

Eun-Pa Lim^{1*}, Harry H. Hendon¹, Ghyslaine Boschat^{2,3*}, Debra Hudson¹,
David W. J. Thompson⁴, Andrew J. Dowdy⁵ and Julie M. Arblaster^{2,3*}

Underpinning science example

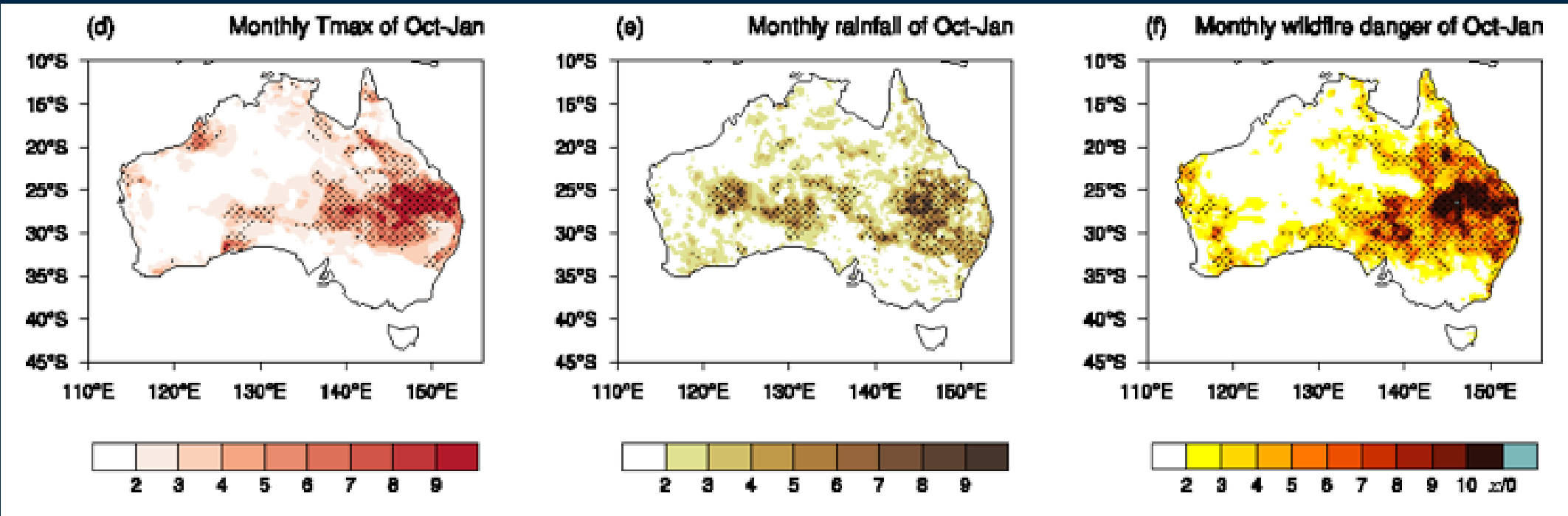


Stratospheric warmings increase risk of ...

Heat

Dry

Fire danger

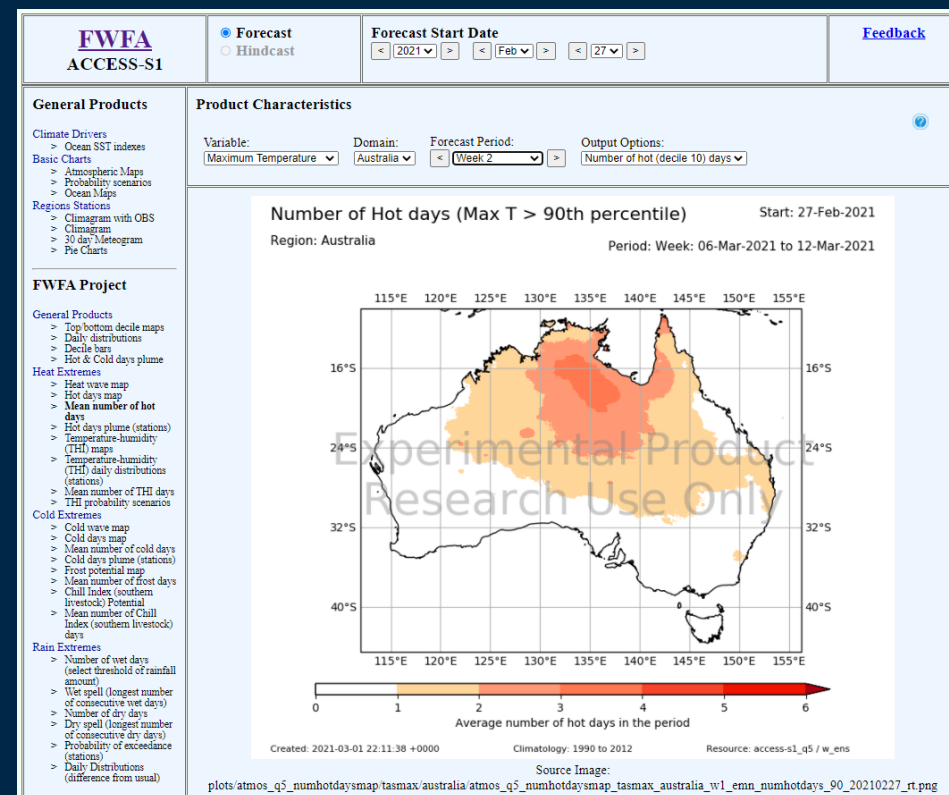


Increased chance of extreme (outer decile) hot, dry and fire danger conditions in stratospheric vortex weakening (warming) years.

Developing and delivering new forecasts

- Develop a range of heat, cold and rainfall multi-week & seasonal experimental forecast products from ACCESS-S
- Make experimental products available on a research web server for trial and feedback

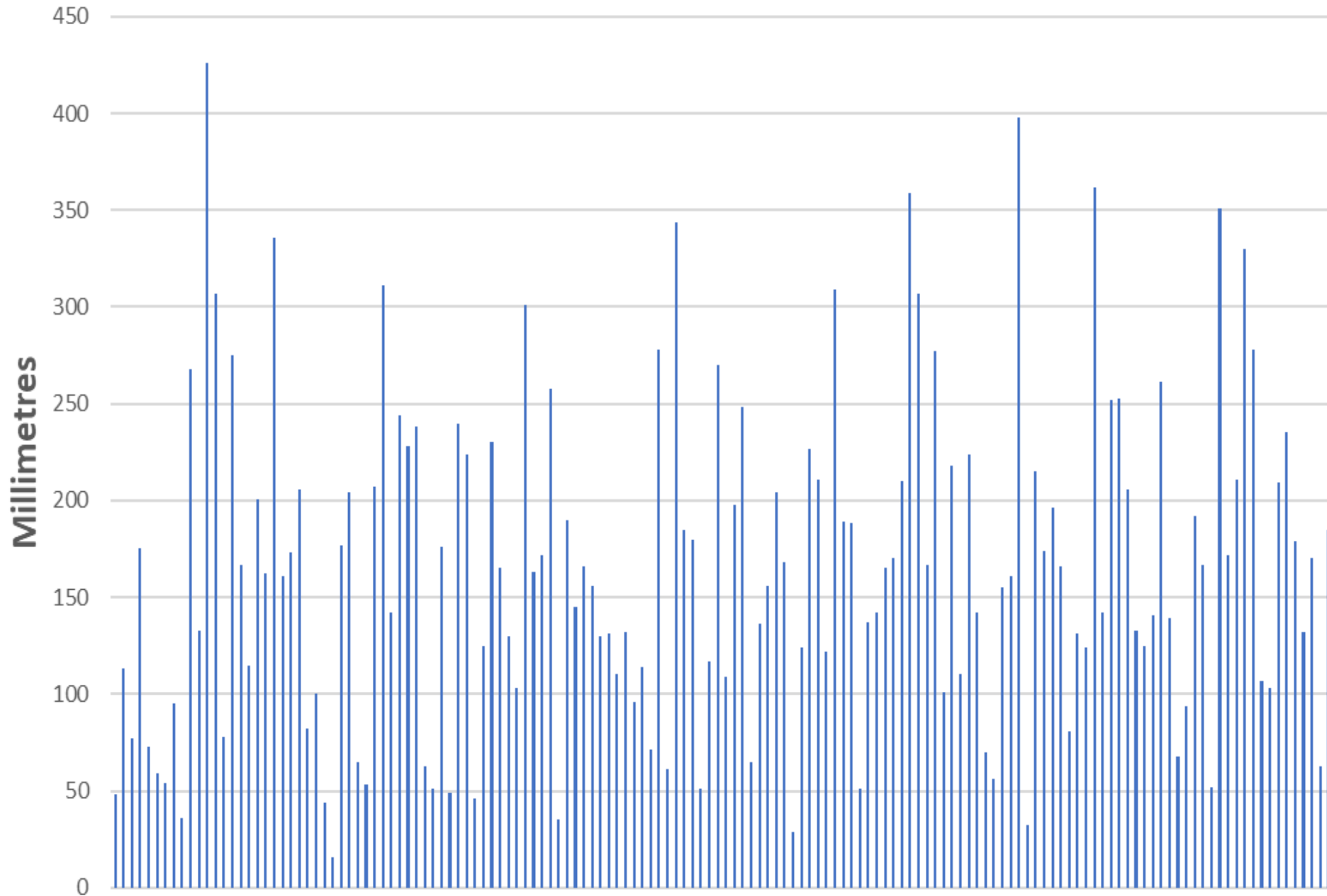
Product name	---SELECT--- Category of feedback	Feedback	Other comments (e.g., who provided the feedback)	Feedback added by <NAME>, <date>	Response from BoM	Feedback categories
Quantile bars	Interpretation	Can you produce an alternative display of the bars - "stretched out" version?	Feedback from Peter Hayman	Debbie (8/11/18)	Done. Alternative display of the decile bars is available	Look and feel
Quantile bars & pie charts	Look and feel	Remove decimal points (for percentages in quantile)		Debbie (8/11/18)	Done	Interpretation
Daily distributions	Interpretation	How significant is the shift of the forecast w/climatology?	Feedback from Rich Eckard (and others)	Debbie (8/11/18)		Utility
General	Look and feel	Dates with separators in the product images e.g. 2018-01-10 instead of 20180110	Feedback from Rich Eckard	Debbie (15/11/18)	This has been implemented	Other
General	Utility	Add an upcoming (rather than calendar) month forecast i.e., week 1 week 4	Feedback from Graeme	Debbie (15/11/18)	We have added weeks 1-4 to the Basic Charts (Atmospheric Maps) in the General Products section to start evaluating the timescale. One issue which we need to resolve is a potential discrepancy between the Month 1 and Weeks 1-4 forecasts when the forecast start date is near the beginning of the calendar month. The reason is that, currently, the ensembles for the two timescales are constructed slightly differently. This is a work in progress.	
General	Utility	Can we show a site graph that has last 6 mths rainfall (season progress compared to normal) and then adds the access-S ensemble plume for next 3 mths?	Feedback from Graeme	Debbie (15/11/18)	Good idea. We have added it to our to-do list.	
Forecast periods	Utility	I am questioning the need for the week 1+2 period when week 2 is available by itself. I would imagine the one week weather forecast would have more skill than ACCESS-S, so this is confusing the weather/climate divide, or valuably adding to it? I'm not sure. I work in weeks, so to get a feel for week 4 at the moment I have to mentally subtract week 3 from 3+4. Good for thought, but if week 4 has low skill then don't present it, or present week 4 by itself but with all the usual caveats of low skill. A number of world agencies present maps with a toggle for skill maps, which are a pretty black conformer but show you a feel for where it	Dale Grey	Dale Grey (21/11/18)	The current multi-week periods that are displayed operationally (http://www.bom.gov.au/climate/outlooks/ir/rainfall/index) are week 2, week3, weeks 2+3, weeks 3+4. Weeks 1+2 was not included for the reason you provide. Week 4 is not included because the skill is typically very low. The fortnights are included because they tend to give better predictive skill than the weeks. However, the fact that you do not find the fortnightly periods useful is good feedback - we will convey the feedback to our services section (and will be good to hear if they have had similar feedback).	



- Feedback from reference groups of users in the dairy, beef, sheep, grains, sugar and wine industries.
- Deliver five operational products in a staged approach

Warning- the following slides contain maths

Historic Nov-Jan Rainfall Dubbo



Years 146

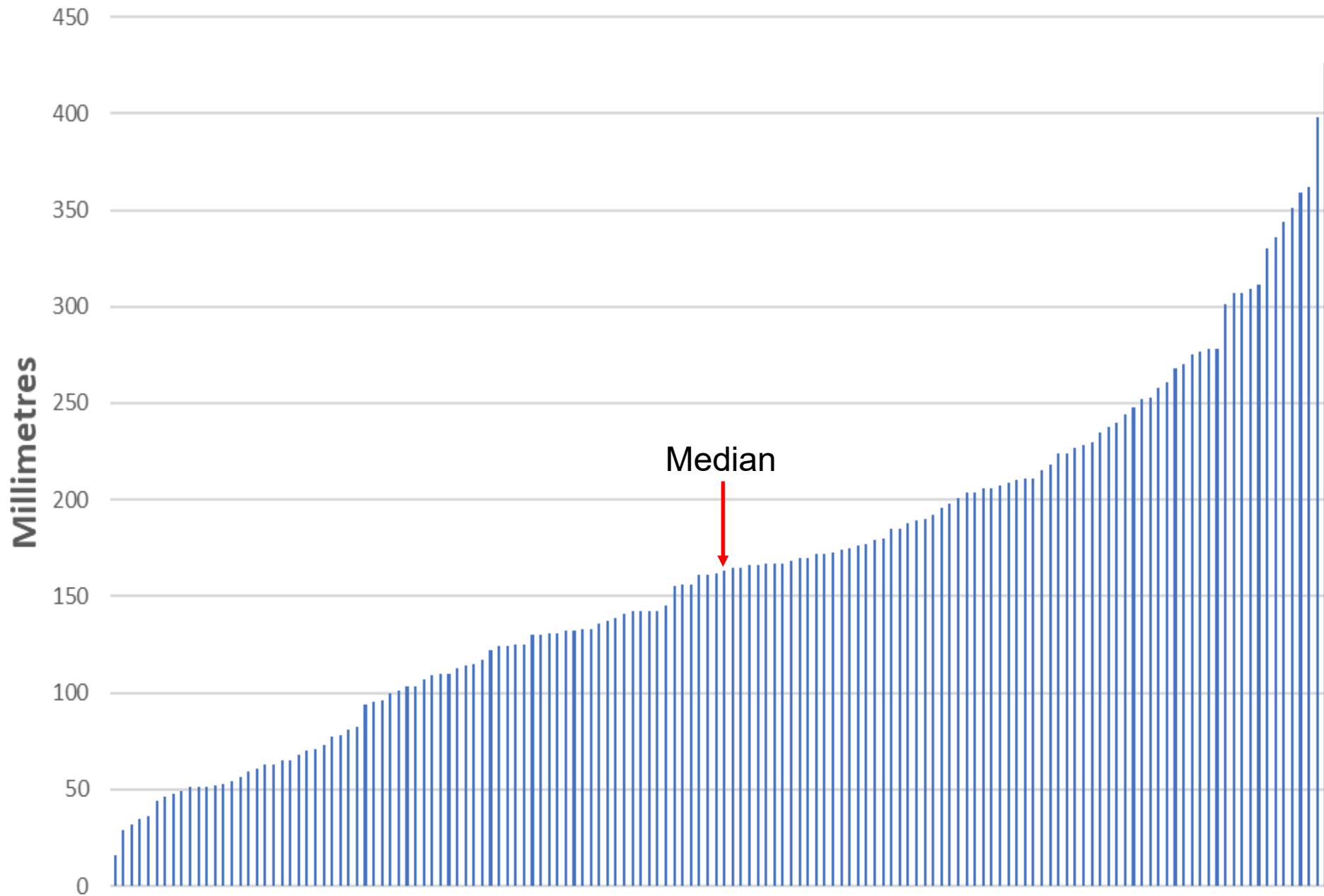
Average 165 mm

Median 163 mm

Lowest 16 mm (1901)

Highest 426 mm (1886)

Historic Nov-Jan Rainfall Dubbo

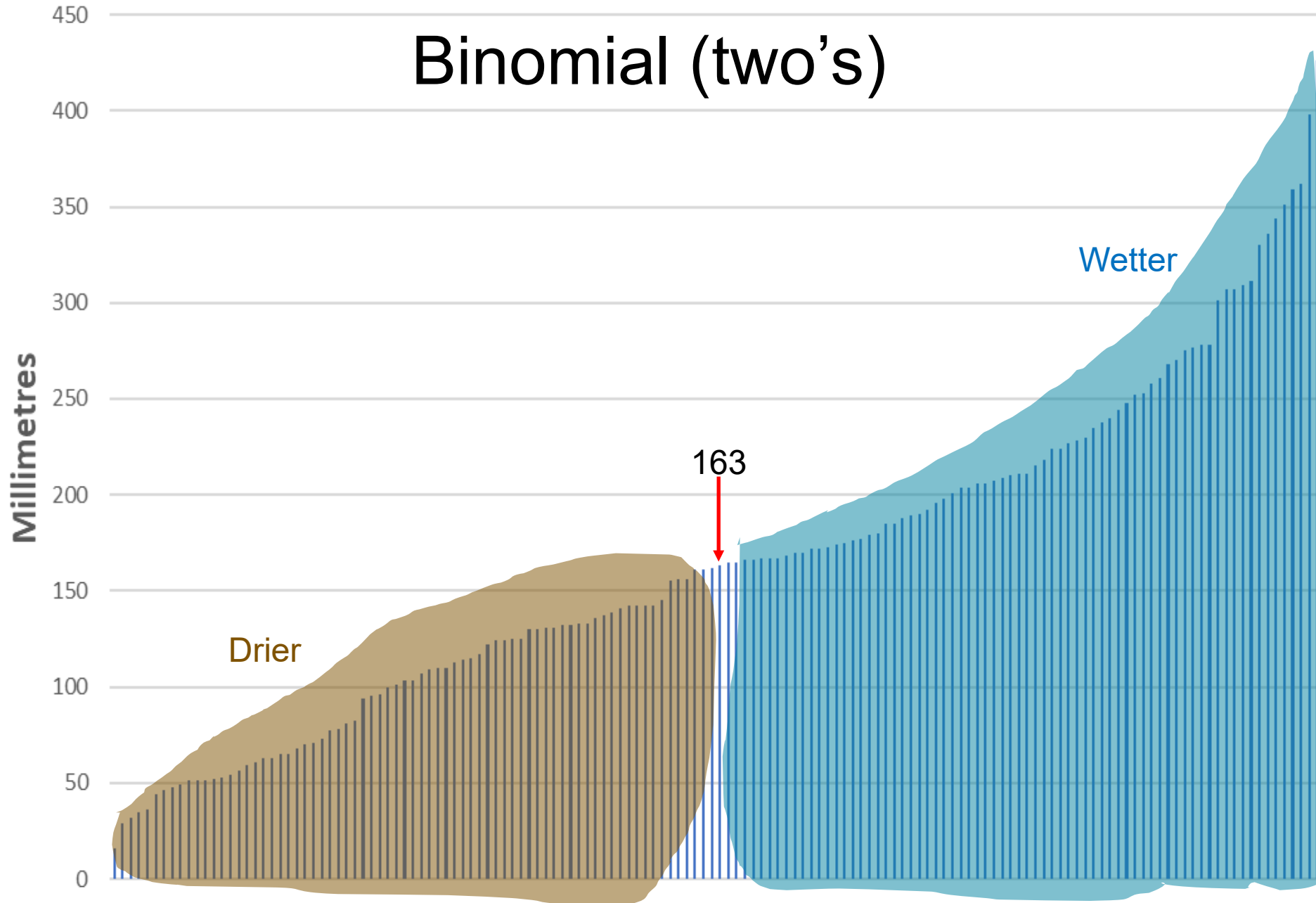


Years 146
Average 165 mm
Median 163 mm
Lowest 16 mm (1901)
Highest 426 mm (1886)

Same data, sorted

Historic Nov-Jan Rainfall Dubbo

Binomial (two's)



50% of the data has been “drier” than the median

50% of the data has been “wetter” than the median

No information on the “normal” or “average”

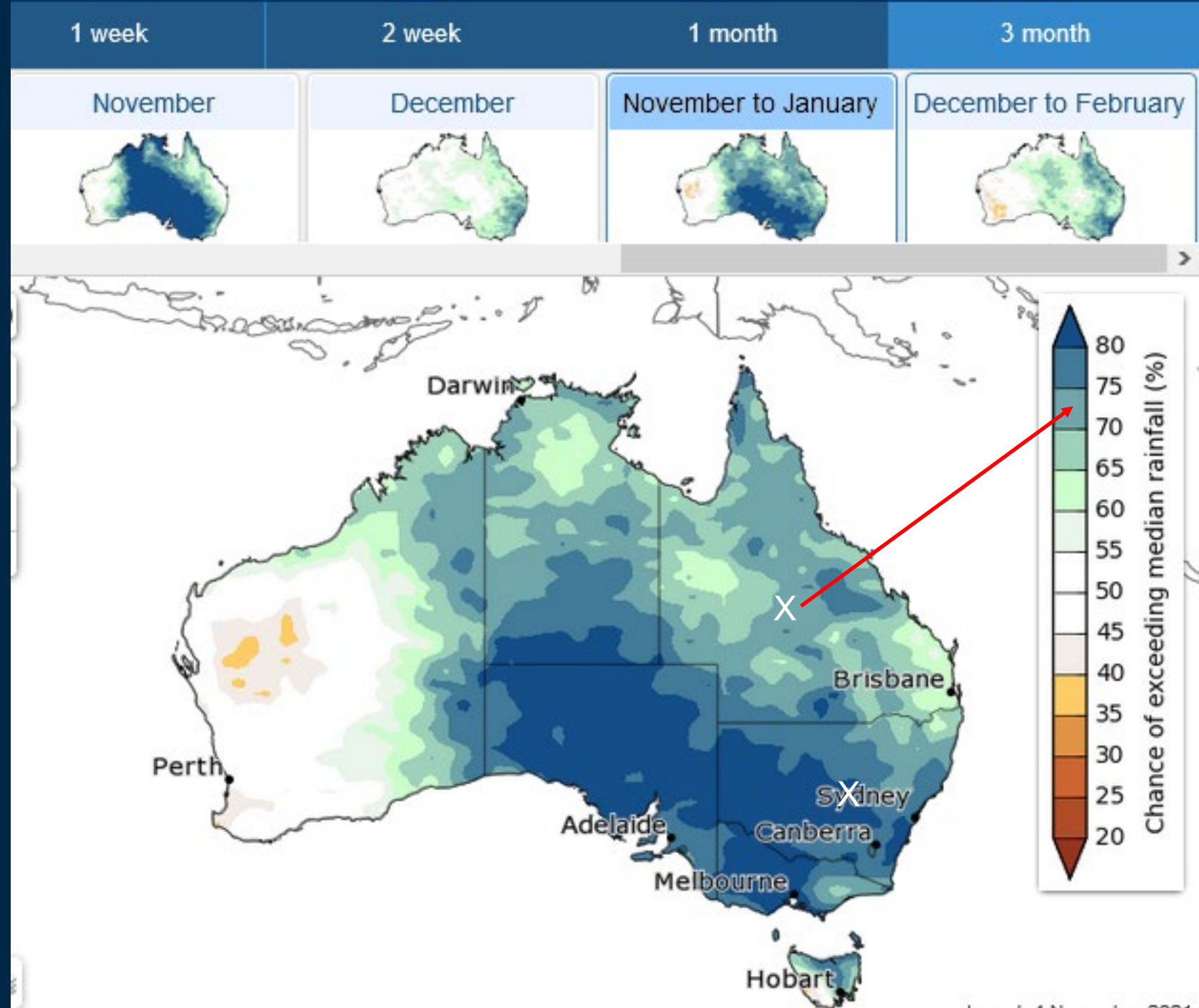
It's one or the other!

There is historically a 50% chance of rainfall falling either side of the median.

From 99 model runs-

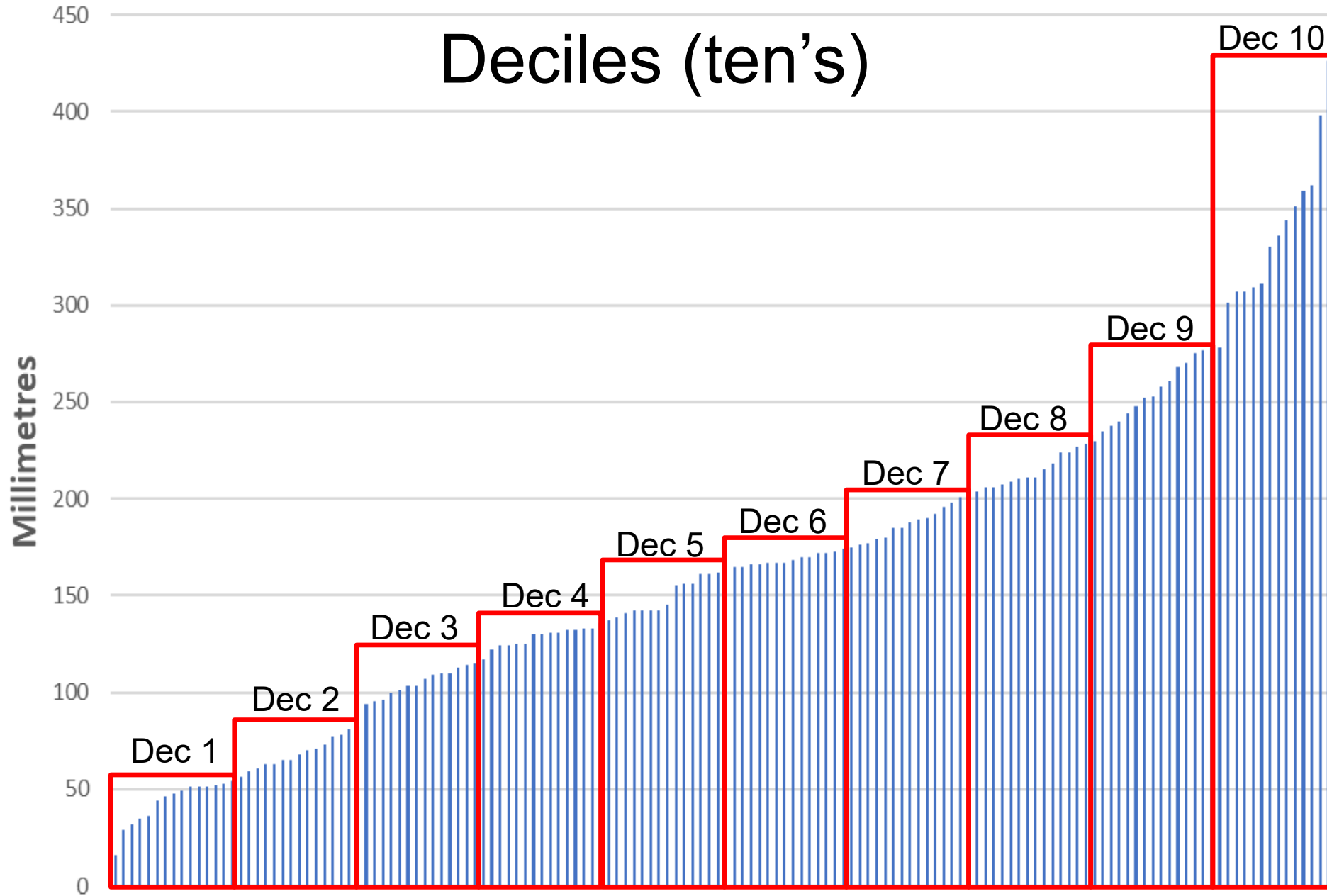
At Longreach a 70-75% chance of exceeding the median, increased chances of wetter compared to the 50% chance long term.

....but a 25-30% chance of being less than the median. Even at Dubbo an 80% chance of exceeding the median does not guarantee it will be wet, still a 20% chance of it being drier. A 50% chance doesn't mean average rainfall, it means anything could happen, or a neutral forecast



Historic Nov-Jan Rainfall Dubbo

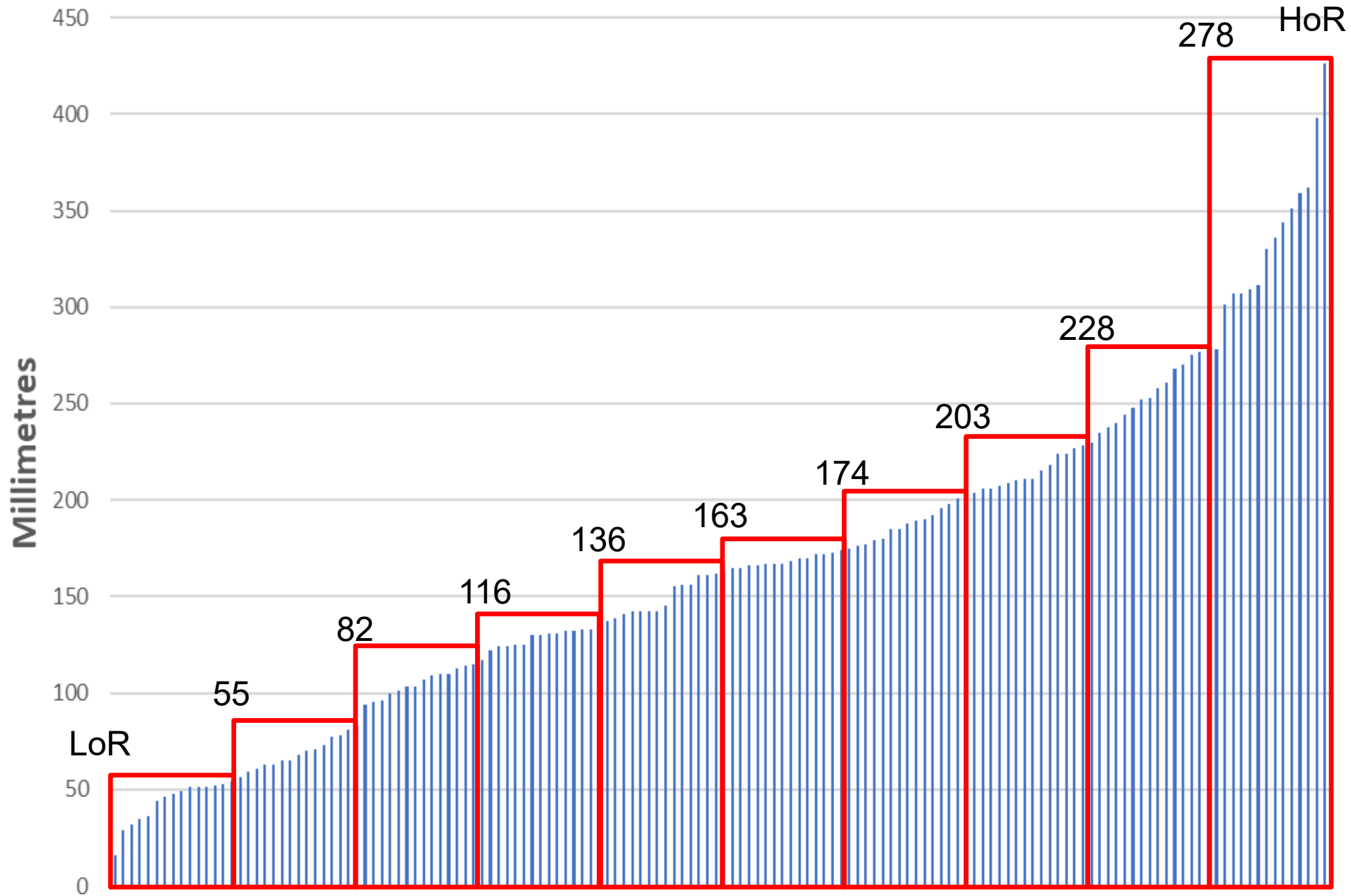
Deciles (ten's)



Data divided into equal tenths

There is historically a 10% chance of rainfall falling in each decile.

Historic Nov-Jan Rainfall Dubbo



Decile 1 16-55 mm

Decile 2 55-82 mm

Decile 3 82-116 mm

Decile 4 116-136 mm

Decile 5 136-163 mm

Decile 6 163-174 mm

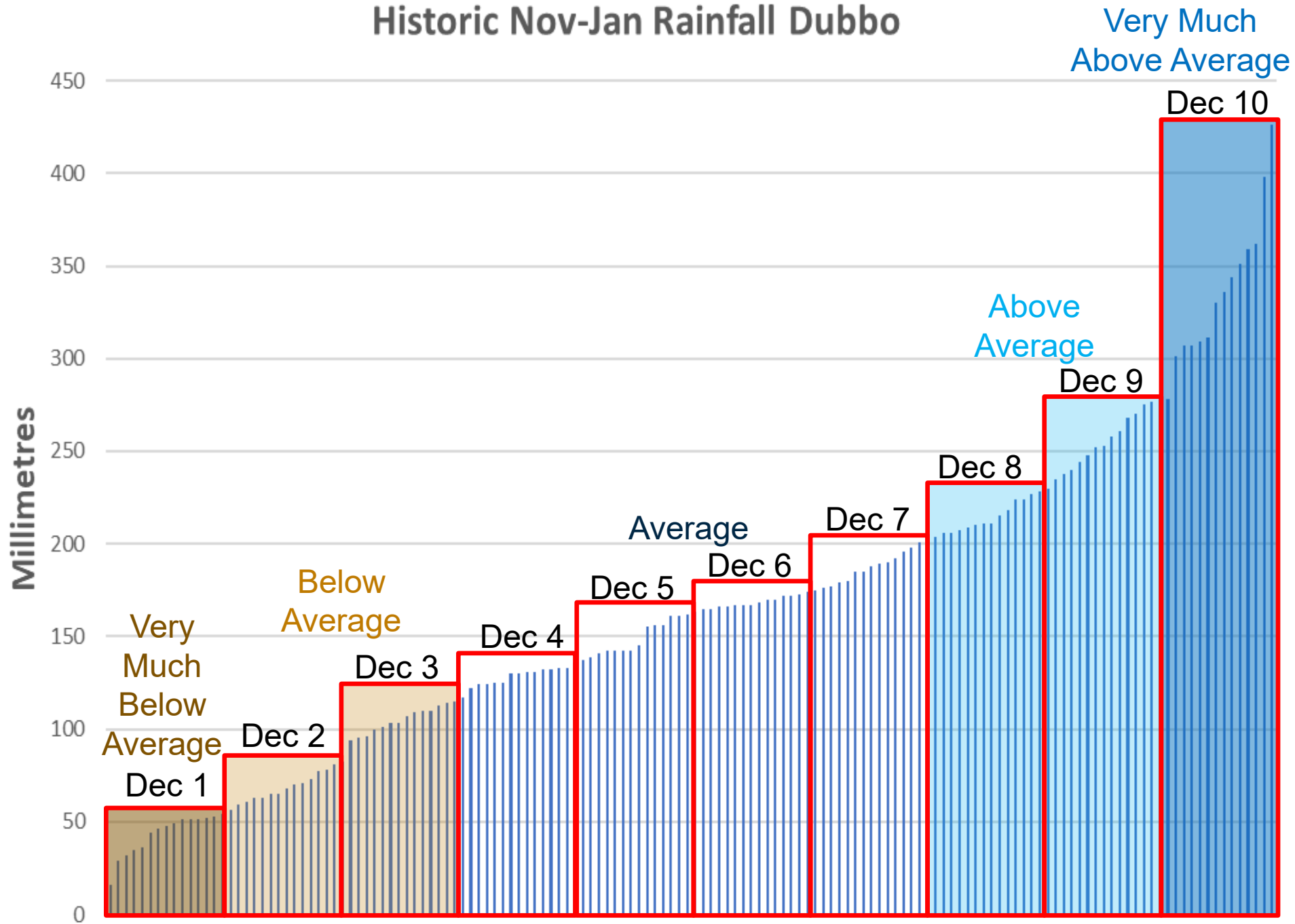
Decile 7 174-203 mm

Decile 8 203-228 mm

Decile 9 228-278 mm

Decile 10 278- 426 mm

Historic Nov-Jan Rainfall Dubbo



These descriptive words are not creative writing!

Decile 1 Very much below average

Decile 2-3 Below average

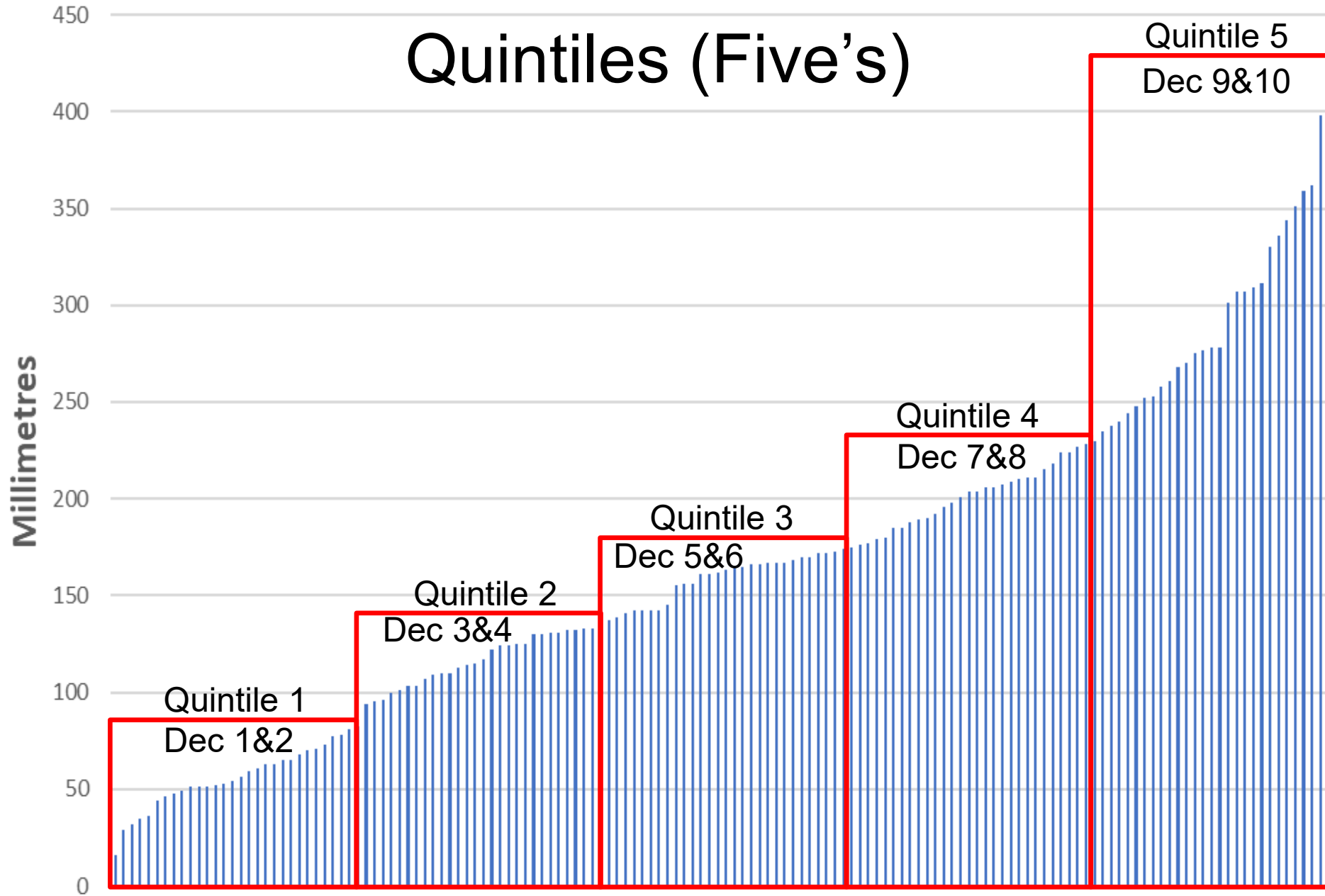
Decile 4-7 Average

Decile 8-9 Above average

Decile 10 Very much above average

Historic Nov-Jan Rainfall Dubbo

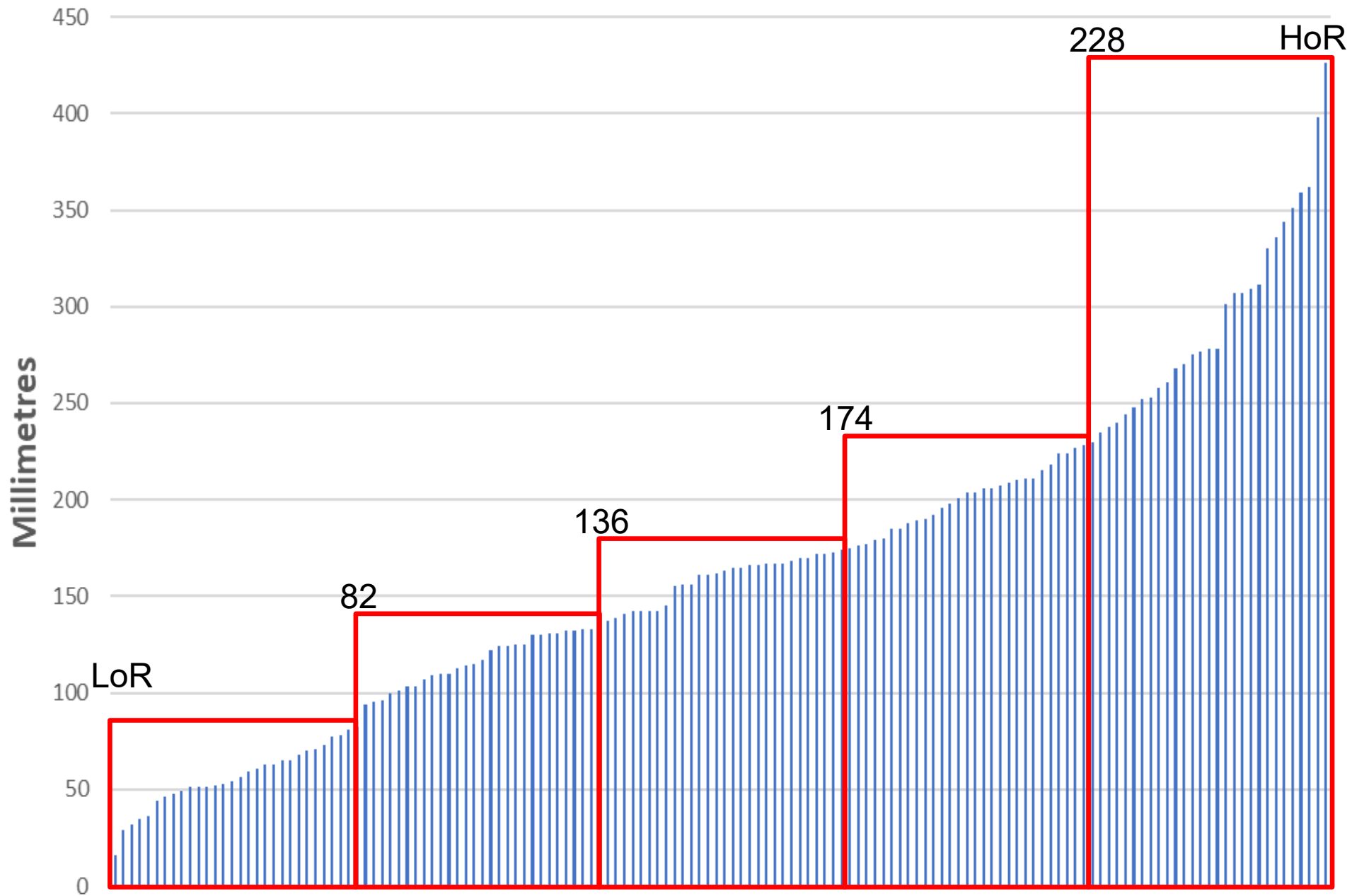
Quintiles (Five's)



Data divided into equal fifths

There is historically a 20% chance of rainfall falling in each quintile.

Historic Nov-Jan Rainfall Dubbo



Quintile 1 16-82 mm

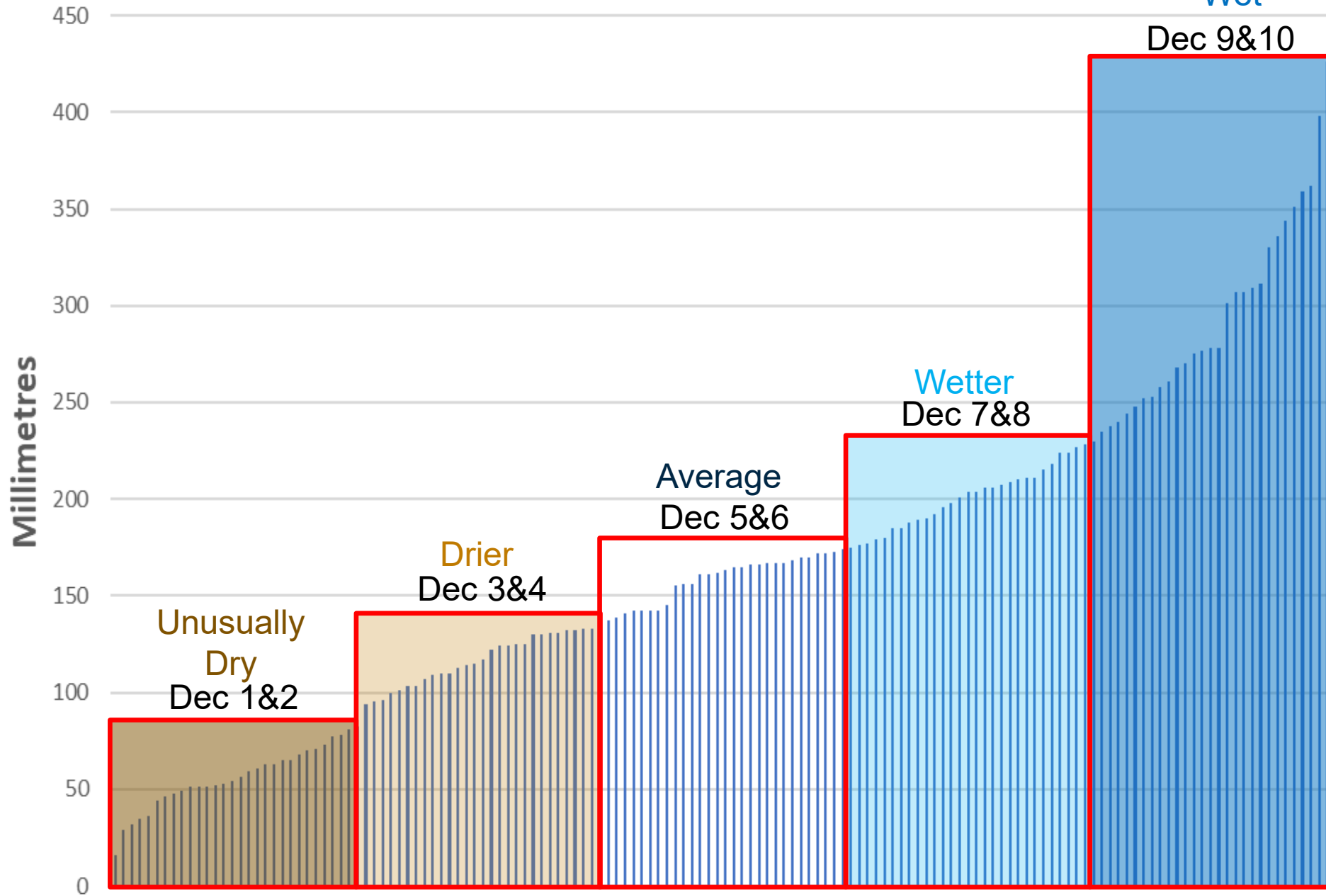
Quintile 2 82-136 mm

Quintile 3 136-174 mm

Quintile 4 174-228 mm

Quintile 5 228-426 mm

Historic Nov-Jan Rainfall Dubbo



Dec 1&2
Unusually Dry

Decile 3&4 Drier

Decile 5&6 Average

Decile 7&8 Wetter

Decile 9&10
Unusually Wet

There is historically a
20% chance of rainfall
falling in each quintile /
2 decile grouping.

The FWFA project has defined for the purposes of forecasting extremes.

Decile 1&2 rainfall “Unusually Dry”.

Decile 9&10 rainfall “Unusually Wet”.

Decile 1&2 Max. temperature “Unusually Cool” day temp.

Decile 9&10 Max. temperature “Unusually Warm” day temp.

Decile 1&2 Min. temperature “Unusually Cool” night temp

Decile 9&10 Min. temperature “Unusually Warm” night temp.

The analysis and forecasts are being done at intervals of weeks 1, 2, 2+3, months 1, 2, months 1-3 and 2-4.



Operational Products #1 and #2

1. Maps showing likelihood of very cold/hot and very dry/wet

Maps that indicate the chance of having extreme (deciles 1&2 and deciles 9&10 respectively) rainfall, maximum (Tmax) and minimum temperature (Tmin) for the weeks, months and seasons ahead

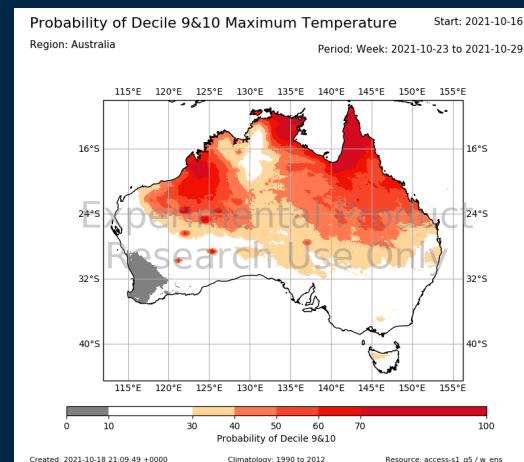
2. Decile/quintile bars

Location-specific bars that indicate the shift in the probabilities compared to usual across the deciles. Available for rainfall, maximum (Tmax) and minimum temperature (Tmin) for the weeks, fortnights, months and seasons ahead

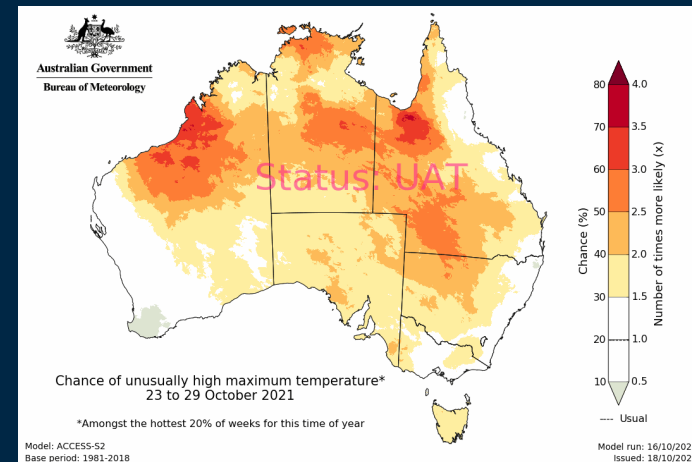


Australian Government
Bureau of Meteorology

Examples from the experimental products website (ACCESS-S1)

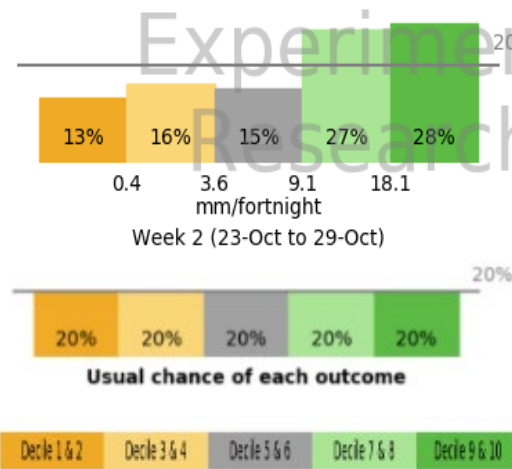


Transition to "services" and the BoM public website (ACCESS-S2)

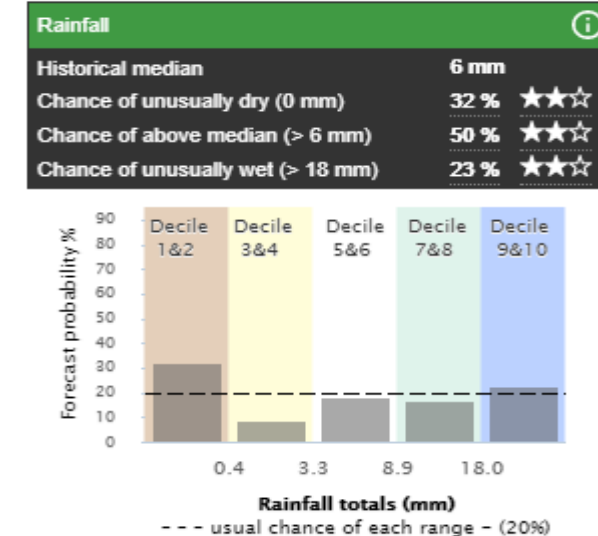


Rainfall Decile Bars

Region: Moree



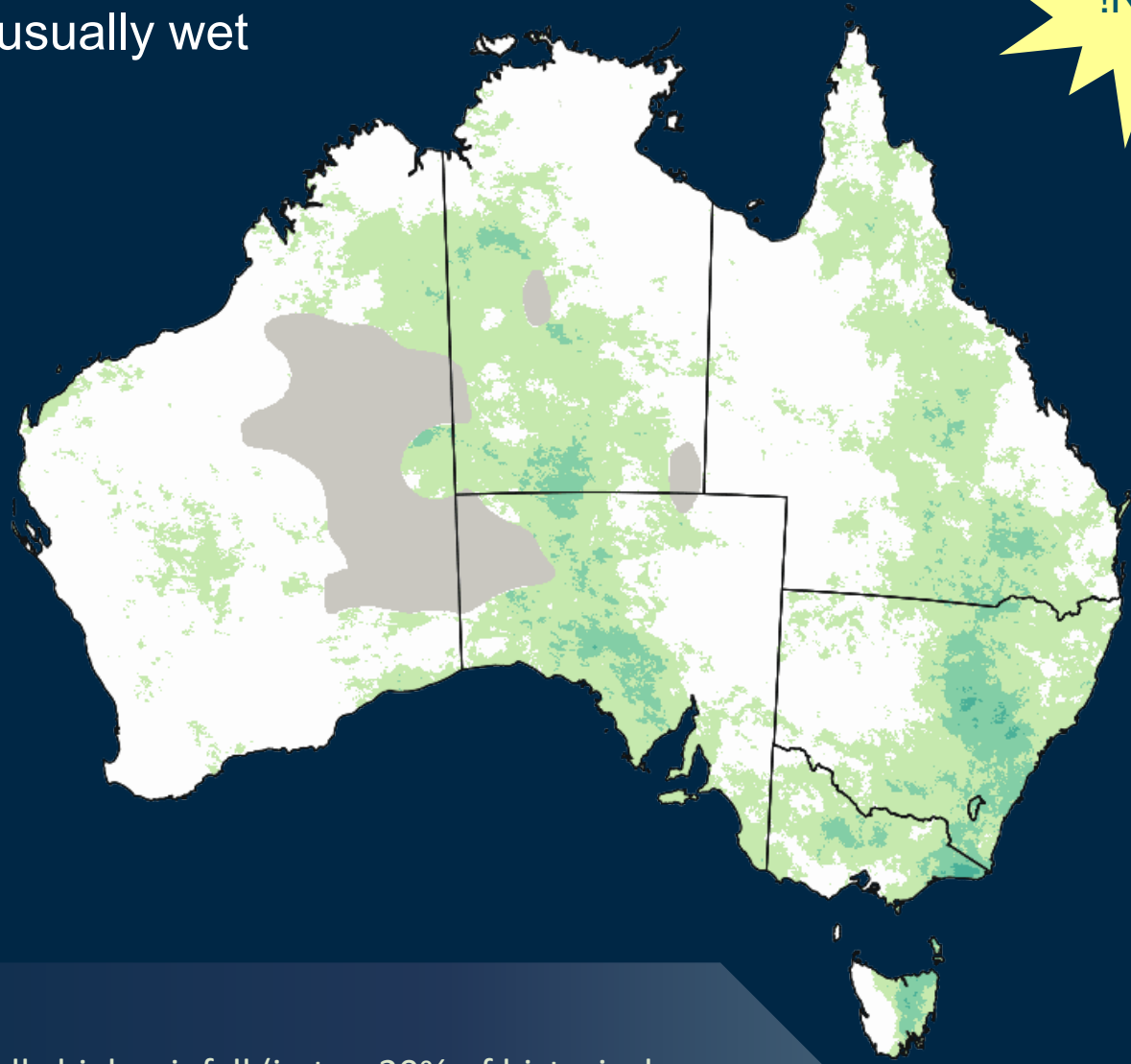
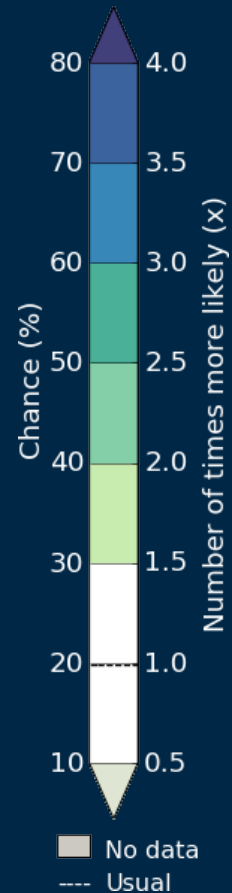
Outlook for 23 Oct – 29 Oct at Moree





November 2021 – January 2022

Chance of unusually wet



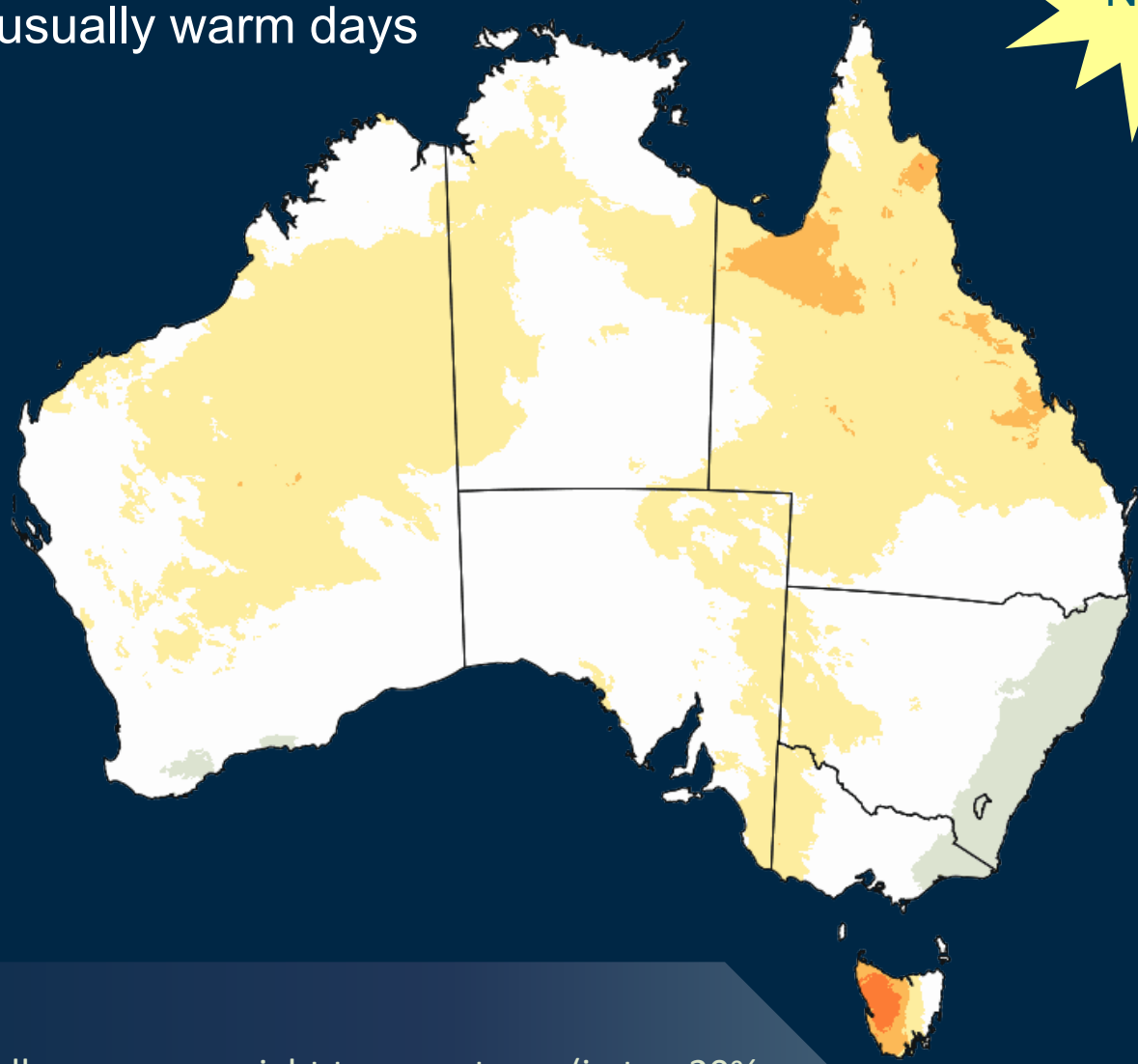
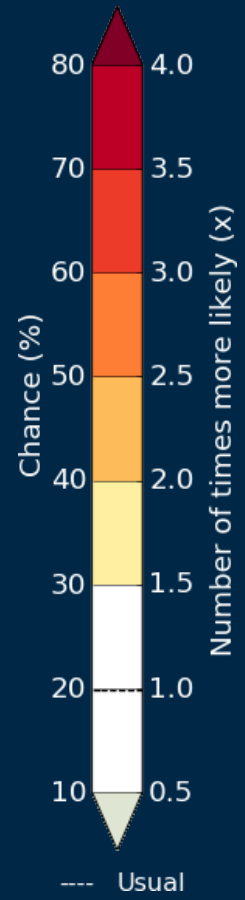
- **New!** 'Chance of extreme' outlook maps for upcoming weeks, months, seasons
- For rainfall, maximum/minimum temperature
- Drill down to specific locations
- Explore these new maps at: <http://www.bom.gov.au/climate/outlooks/>

- Increased chance of unusually high rainfall (in top 20% of historical observations) in parts of eastern Australia, SA and the NT.



November 2021 – January 2022

Chance of unusually warm days



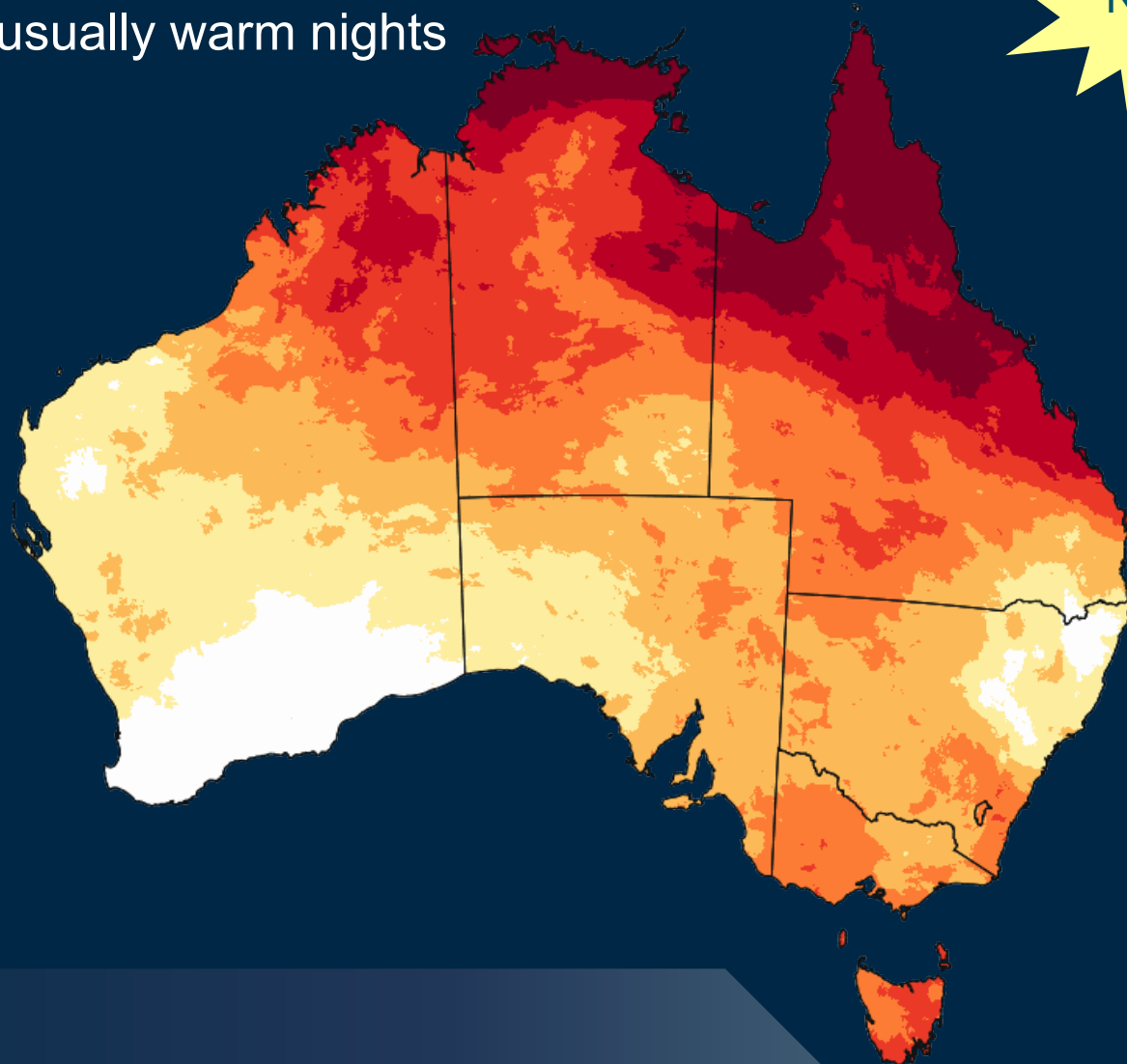
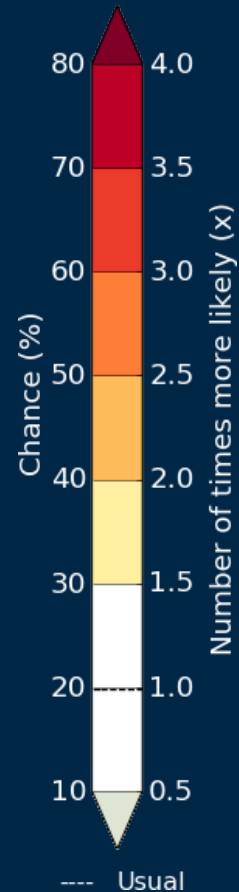
- **New!** 'Chance of extreme' outlook maps for upcoming weeks, months, seasons
- For rainfall, maximum/minimum temperature
- Drill down to specific locations
- Explore these new maps at: <http://www.bom.gov.au/climate/outlooks/>

- Increased chance of unusually warm overnight temperatures (in top 20% of historical observations) across much of the country.



November 2021 – January 2022

Chance of unusually warm nights



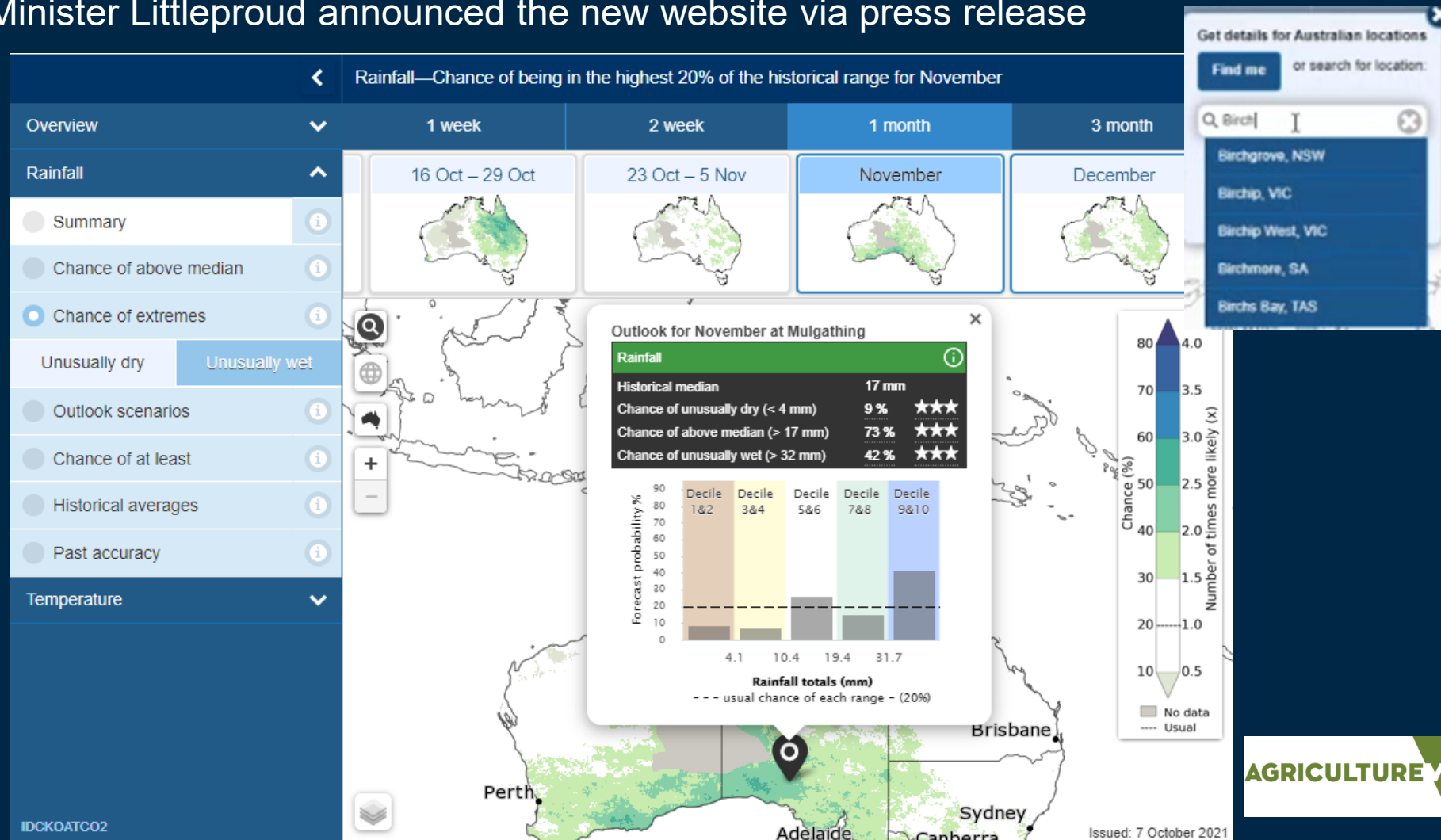
- **New!** 'Chance of extreme' outlook maps for upcoming weeks, months, seasons
- For rainfall, maximum/minimum temperature
- Drill down to specific locations
- Explore these new maps at:
<http://www.bom.gov.au/climate/outlooks/>

Increased chance of unusually warm overnight temperatures (in top 20% of historical observations) across much of the country.

Climate outlooks – now with climate extremes

- ACCESS-S2 is now live and supporting FWFA extremes products
- FWFA Products #1 (extremes maps) & #2 (quintile bars) were put on the BoM website on 1 November 2021 ☺
- Minister Ley and Minister Littleproud announced the new website via press release

• [Demo](#)



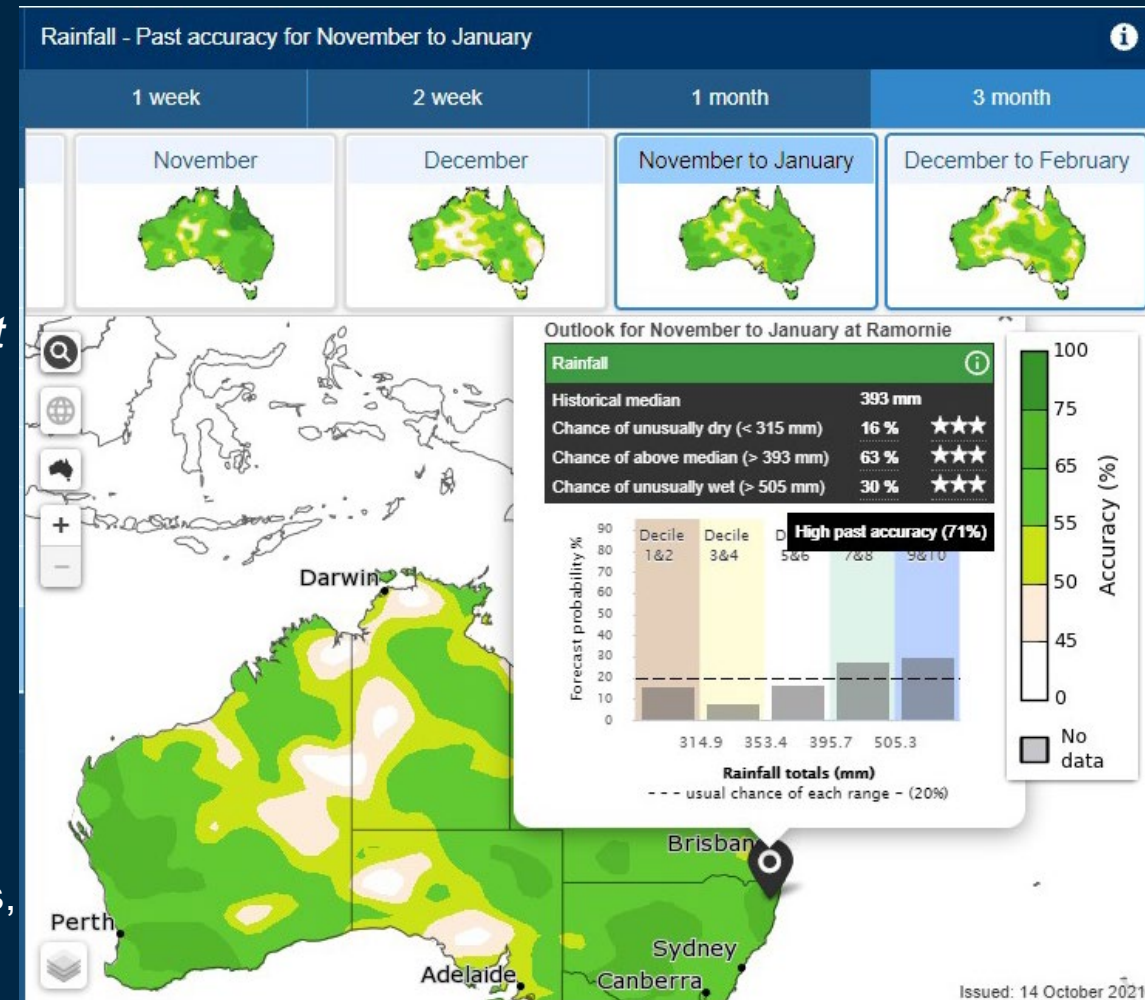
Australian Government
Bureau of Meteorology



Past Accuracy

- the ROC score

- Extremes forecasts have been tested over the period 1981- 2018
- We **don't** use percent correct as most of the time we don't forecast extremes and then don't observe extremes, so our *percent correct score would be bloody brilliant!*
- Its like forecasting tornados – if you always say "no tornado is forecast" you'll be correct 99.9% of the time!
- Instead use Relative Operating Characteristics (ROC)
- A score below 50% says you cry wolf a lot (false alarms) – take extremes forecasts here with a grain of salt
- Green areas on the map say "when there is a forecast for extremes, most times you get an extreme" (hits) – take care in these regions
- The darker the green, the more confidence we have in the forecast



Potential uses and applications

- Nitrogen spreading in crops where rain is needed in two weeks.
- Hay making where curing to baling might take two weeks.
- Fungicide application decision in viticulture and horticulture where warm/wet weather at critical times demands protective coverage.
- Harvesting logistics for viticulture and horticulture and grain crops needing rain free.
- Sugar cane harvesting logistics requires a run of rain free weather.
- Minimising environmental impacts of heavy rain when applying fertilisers and pesticides.
- Planning of sheep shearing and lambing paddocks if cold/wet is coming.
- Planning of water supplies for livestock in rainfed areas.
- Planning for the locking up of fodder paddocks.
- Dryland summer cropping decisions requiring follow up rain.
- Critical irrigation timing at sensitive crop stages, where heat maybe detrimental.
- Planning of livestock shelter, feed and water supply when a heat wave might be coming.
- Pasture paddock management when too wet is forecast
- Water Trading – planning for which areas may need water or will receive good rainfall soon

Early feedback from farmers and collaborators

"Whilst weather forecasting is not an exact science, these tools will be **really valuable in planning our work program** on a seasonal level." *Dairy Farmer*

"These new products give a fuller picture to the seasonal outlook and answer some common questions posed by farmers. Grain farmers point out that it is easy to manage seasons that are slightly above or slightly below the average; **they are interested in the very wet or dry and very warm or cool seasons.**" *SARDI crop researcher*

"They are valuable products. Being forewarned we can **change things around in our system according to what these products are forecasting.**" *Sugar Cane grower*

"These maps are **better than the current probability above or below median** because a farmer wants to know the probability of the drier/ wetter/hotter/cooler and therefore the deciles at the extremes are of more interest." *Beef producer*

"It has been very insightful being a part of this project. To pin down what could be of value in on farm decision making has been challenging. The process of **working with the BoM on these FWFA products highlights the value of a co-design approach** in delivering a useful outcome." *Dairy Farmer*

"Farmers over the last 15 years have always expressed their frustration of the limitations of a plus and minus median forecast. **It is with great joy that will now be able to ascertain how dry, how wet, how hot, how cold, couched in terms of probability** of course!" *Agriculture Victoria Agronomist*



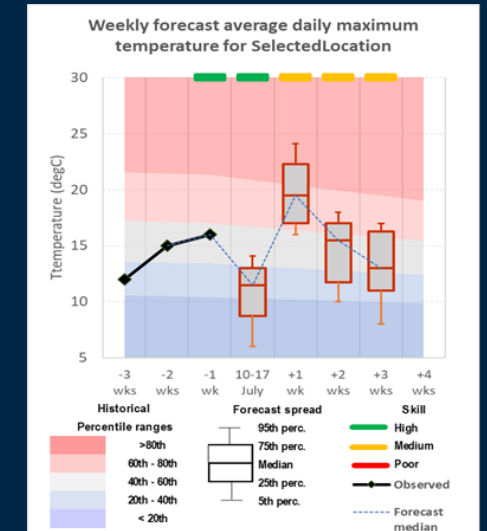
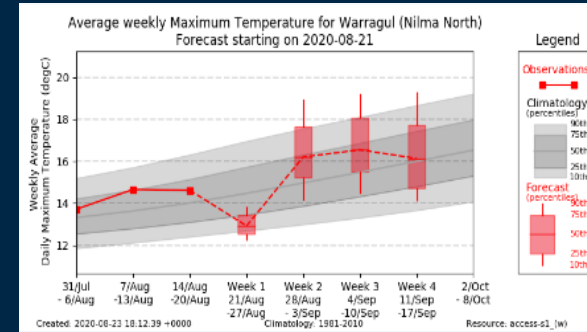
Australian Government
Bureau of Meteorology



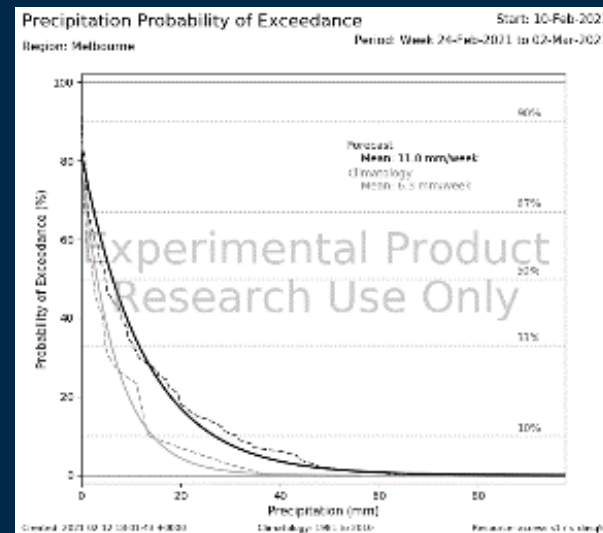
What's next?

- Product #3 goes live end March 2022. User feedback for proposed operational version underway
- Operational design of products #4, #5 being initiated, going live end May 2022

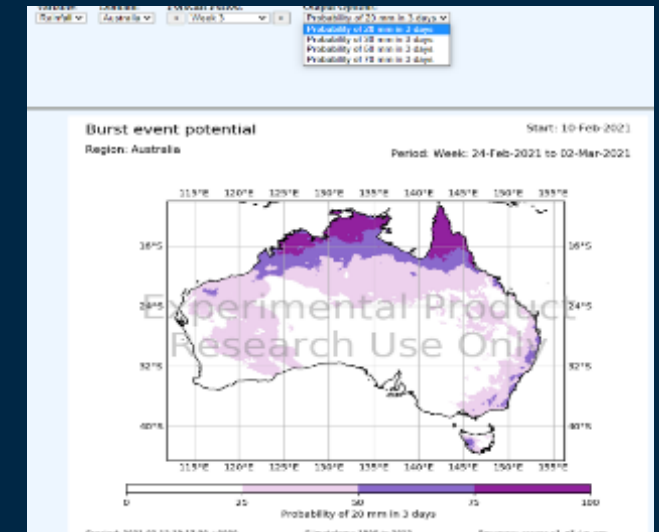
#3 – Location based weekly/monthly time series of rainfall/temperature outlooks (Climagrams)



#4 Location based rainfall probability of exceedance chart



#5 Maps showing heightened probability of rainfall burst



Thank you

Questions?

www.bom.gov.au/climate/outlooks



Australian Government
Bureau of Meteorology

BUREAU OF METEOROLOGY



**CLIMATE
OUTLOOKS**
now forecasting
climate extremes