



Australian Government
Bureau of Meteorology

WGSIP23 (November 2021)

ACCESS-S2: An upgraded seasonal prediction system, including new operational forecast products

Debbie Hudson

Bureau of Meteorology



ACCESS-S1

- UKMO GC2 model
- UKMO initial conditions (NEMOVAR) + BoM ensemble generation
- 23-year hindcast period (1990-2012)
- Real-time products based on time-lagged 99-member ensemble
- Went operational mid 2018

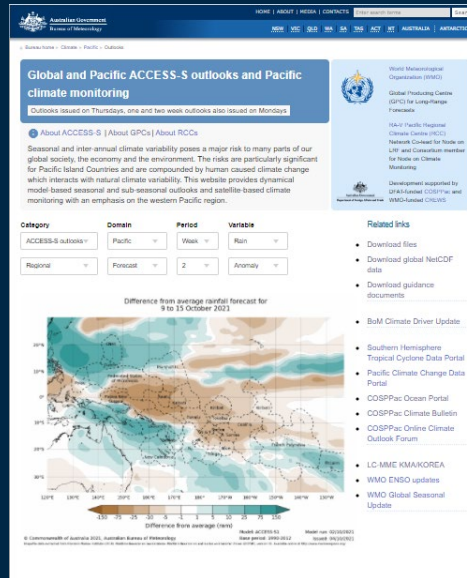


**ACCESS-S
Version 2
"go-live"
19 October
2021**

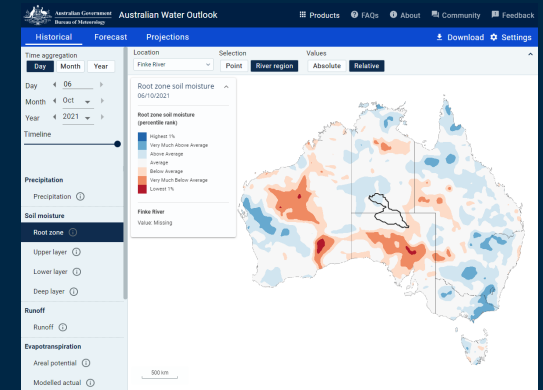
- In-house data assimilation (production of initial states)
- More timely forecasts
- Reduced reliance on UK Met Office for initial ocean states
- Same model, but some enhancements and corrections
- Longer hindcast set (1981-2018)
- Enhanced post-processing



Seasonal Climate Outlook



Seasonal outlook for the Pacific Islands (COSPPac)



ACCESS-S inputs to Water Balance Model (AWRA-L) generates the Seasonal water outlook



Forecast data to several external customers



ACCESS-S2 weakly coupled DA

Based on BoM/CSIRO Coupled EnKF software (Yonghong Yin, Pavel Sakov)

- Weakly coupled daily cycle
- Direct replacement of atmos basic variables
- Ensemble OI in ocean
- Ocean assimilation uses the background state from the coupled model
- Land surface and sea ice indirect through coupling
- Stronger nudging of SST than UKMO
- No altimeter assimilation (only T/S profiles)
- Multi-variate – ocean current increments
- 1981-present re-analyses
- Same perturbation scheme as in ACCESS-S1 for ensemble generation (only the atmosphere is perturbed)

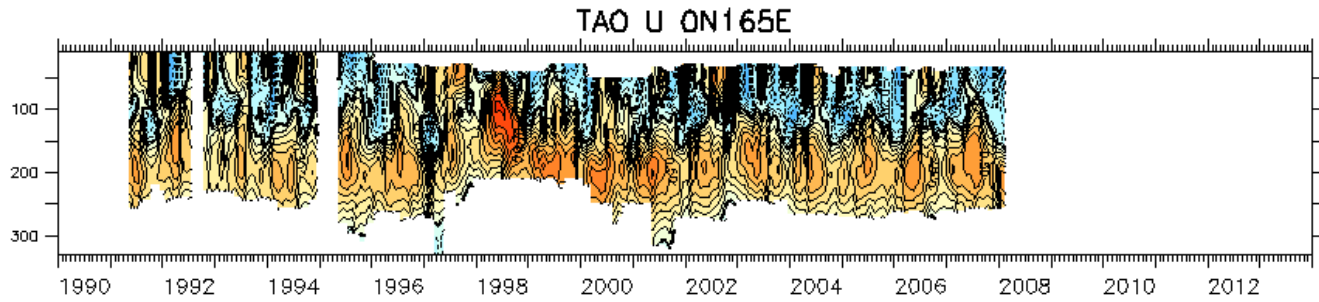


Data assimilation

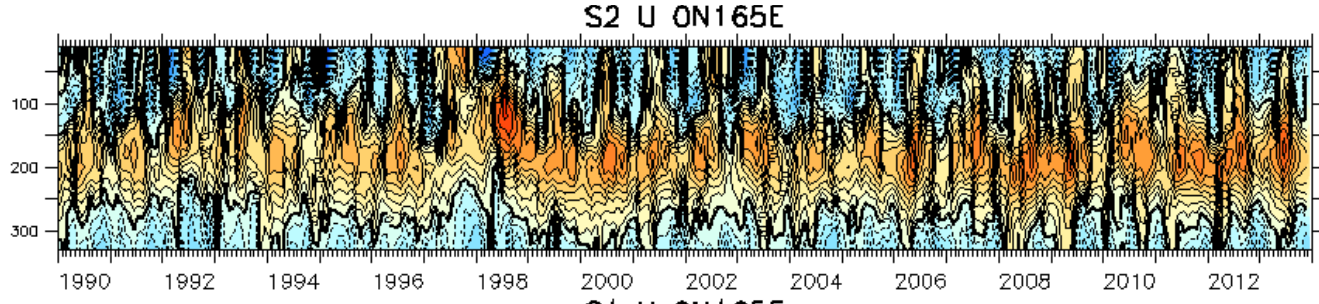
Example: ocean currents are better in ACCESS-S2

U (0N,165E) Monthly mean U from ADCP TAO/TRITON, ACCESS-S2, S1(1990-2013)

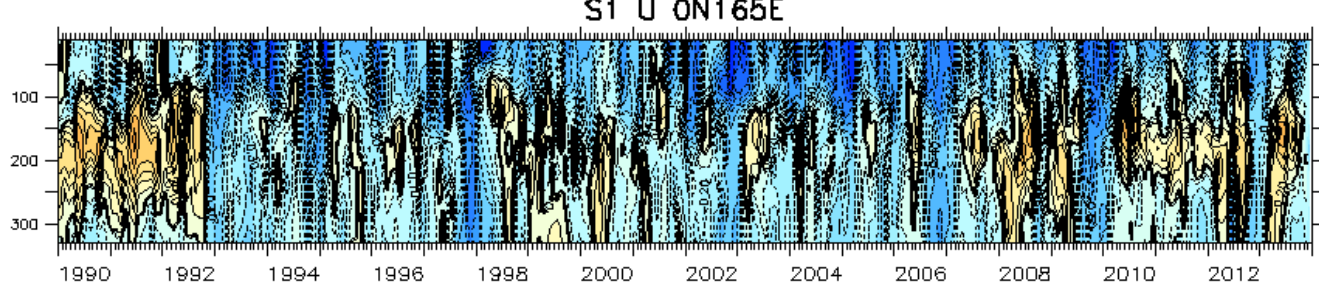
OBSERVED



ACCESS-S2



ACCESS-S1

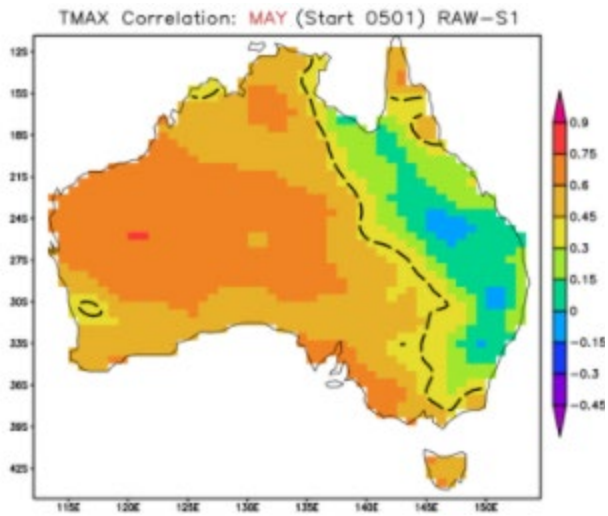




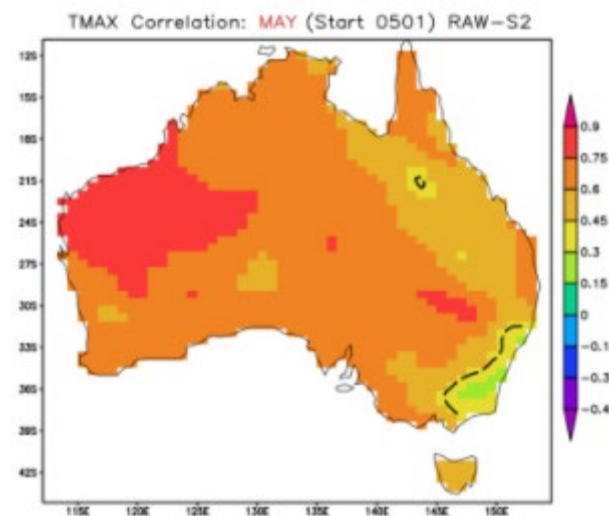
Improved skill over Australia

Maximum temperature: benefits of realistic soil moisture
initialisation

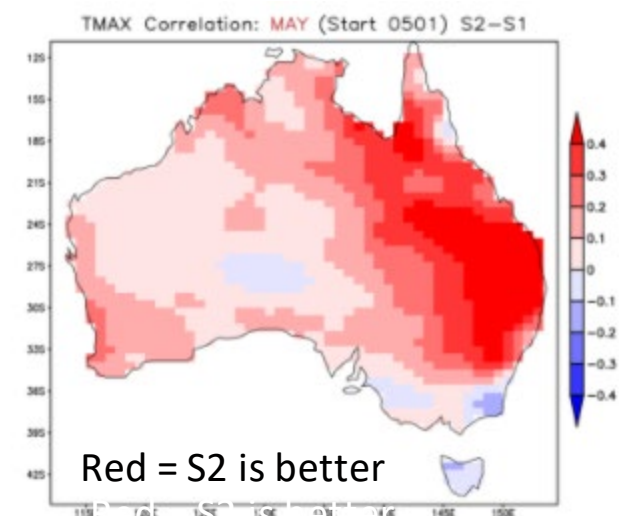
ACCESS-S1



ACCESS-S2



Difference (S2 minus S1)



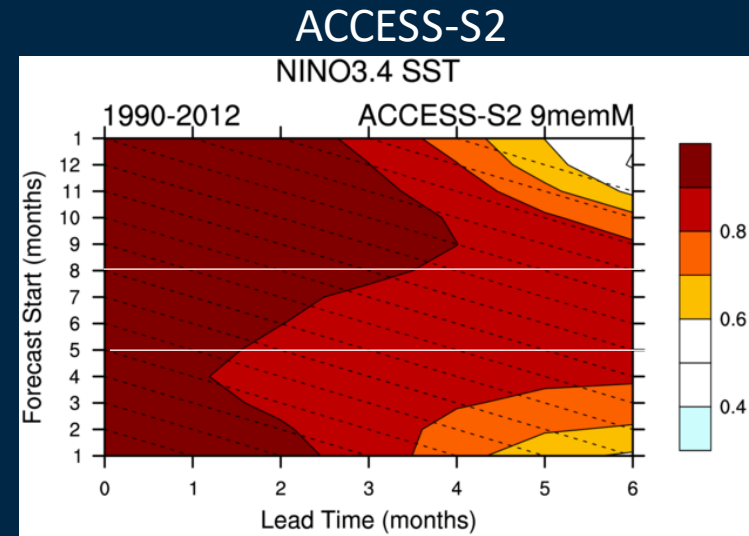
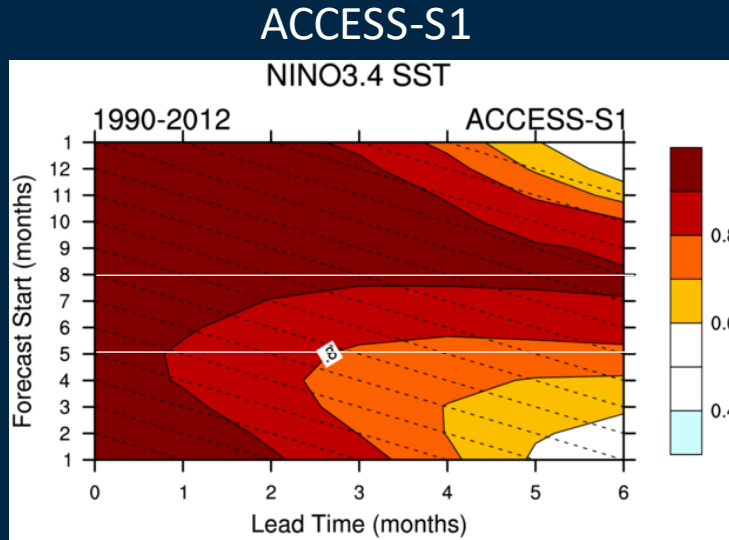
Correlation skill for May (from 1st May Starts)



Improved ocean skill

Some indications of improved forecasts of ENSO, particularly for forecasts started in Autumn

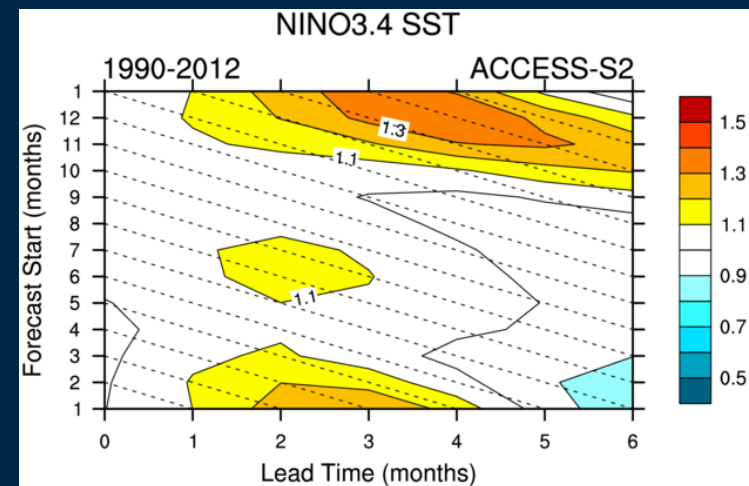
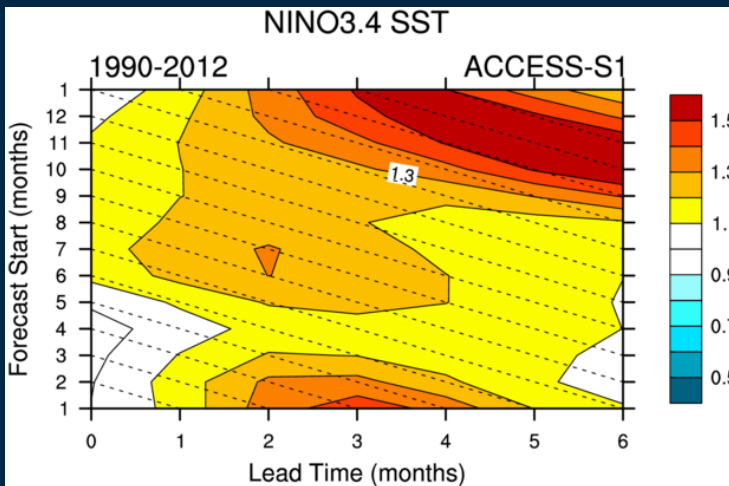
Correlation skill
Redder is better



"Strength" of ENSO

White is good

Ratio of model stddev/obs stddev

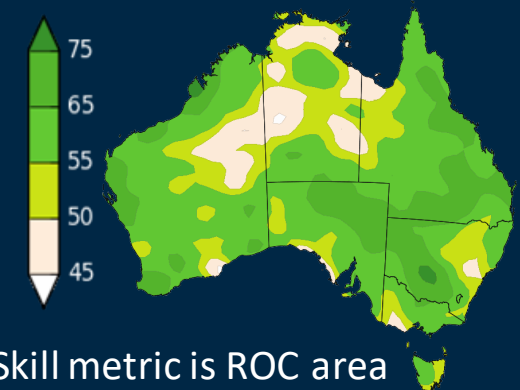
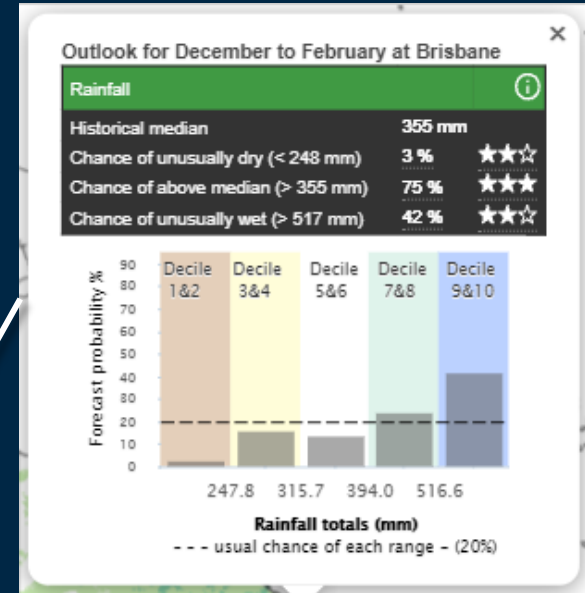
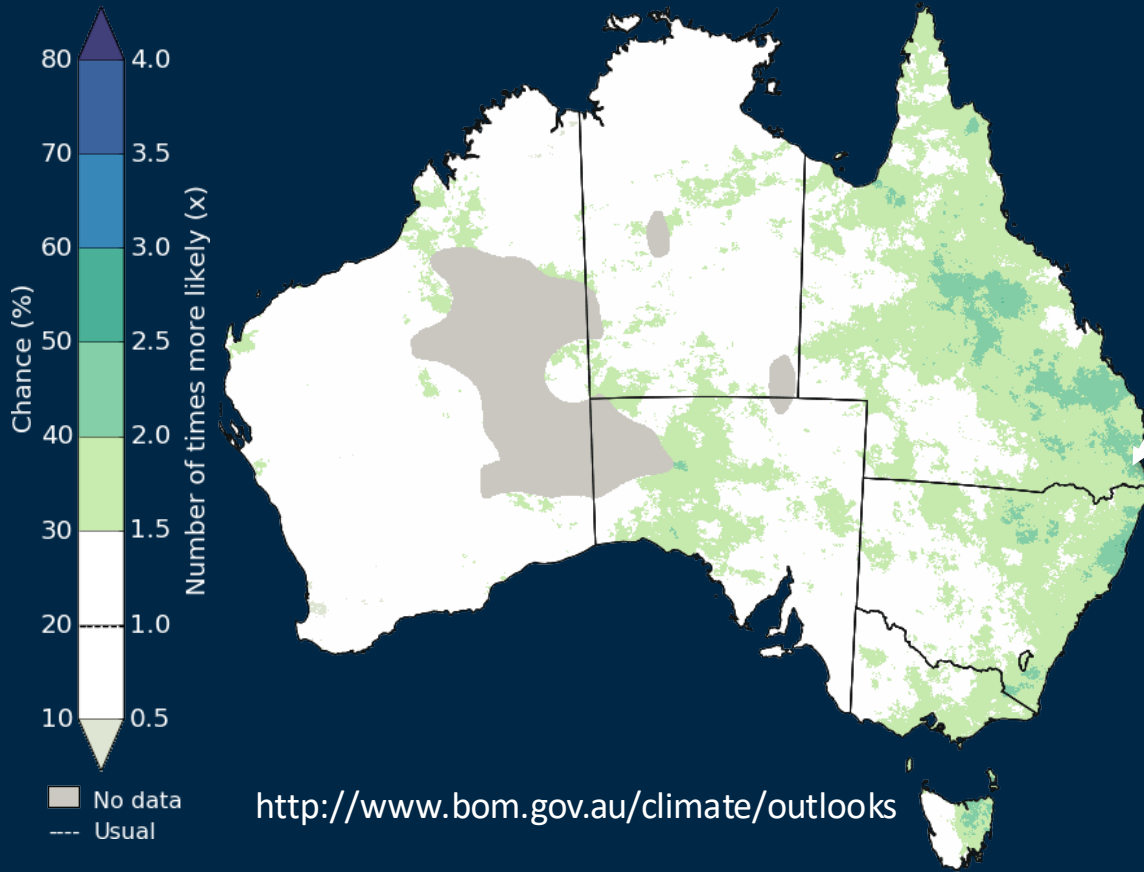




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New products from agriculture "*Forewarned is Forearmed*" project

December 2021 – February 2022 Chance of unusually wet



- Increased chance of unusually high rainfall (in top 20% of climatological period) in parts of eastern Australia.



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Forewarned is ForeArmed (FWFA) (2017-2022)

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



Managing and forecasting "extreme" climate events on multi-week and seasonal timescales

Research partners

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

USERS

Rural RDC partners

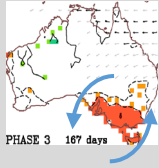
Meat and Livestock Australia
Grains RDC
Sugar Research Australia
Cotton RDC
AgriFutures Australia
Dairy Australia
Wine Australia
Australian Pork



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An end-to-end and well-connected approach

Underpinning Science

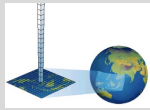


nature
geoscience
ARTICLES
http://dx.doi.org/10.1038/ngeo1909-0464e

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

Eun-Pa Lim¹, Harry H. Hendon¹, Ghyathine Bosché^{1,2}, Debra Hudson¹, David W. J. Thompson¹, Andrew J. Dowdy¹ and Julie M. Arblaster^{1,3,4}

The occurrence of extreme hot and dry conditions in warm seasons can have large impacts on human health, energy and water supplies, agriculture and wildfires. Australian hot and dry extremes have been known to be associated with the occurrence of El Niño and other variations of tropospheric circulation. Here we identify an additional driver: variability of



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RESEARCH ARTICLE

Sub-seasonal to seasonal prediction of rainfall extremes in Australia

Andrew D. King¹, Debra Hudson¹, Eun-Pa Lim¹, Andrew G. Marshall¹, Harry H. Hendon¹, Todd P. Lane¹, Oscar Alves¹

Abstract
Seasonal climate prediction is data has largely focused on probabilistic forecasts of time-averaged extreme conditions. However, here we examine the possibility of making sub-seasonal to seasonal outlooks for daily-scale precipitation extremes in Australia. We first use observational data to show that significant relationships exist between climate modes, such as the El Niño–Southern Oscillation, and indices representing rainfall extremes across much of Australia. The strong theoretical relationship between climate modes and daily rainfall extremes suggest the potential for probabilistic or seasonal outlooks. The current Australian Bureau of Meteorology seasonal prediction system (ACCESS1.0) is examined for performance in predicting rainfall extremes using a range of measures. Ensemble forecasts, consisting of 11 members, have statistical scores during 1996–2012 performance that are comparable to random indices on short lead times (up to 1 month). We note that at short lead times, however, an added benefit of weather prediction is forecast performance drops at lead times of a week or more. Forecast performance is lower

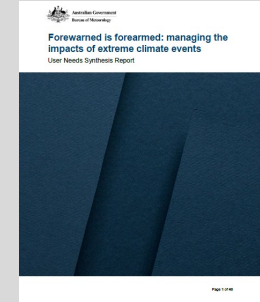
Climate Dynamics
Received 13 July 2016 | Accepted 17 January 2017 | Published online 13 April 2017

Tropical forcing of Australian extreme low minimum temperatures in September 2019

Eun-Pa Lim¹, Harry H. Hendon¹, Li Shi¹, Catherine de Burgh-Daley^{1,2}, Debra Hudson¹, Andrew King¹, Blair Trewin¹, Miriam Corbett¹, Andrew Marshall¹

Abstract
We explore the causes and probability of extreme low minimum temperatures (T_{min}) that occurred across southern and eastern Australia in September 2019. Historically, reduced T_{min} is related to the occurrence of a positive Indian Ocean Dipole (IOD) and central Pacific El Niño. Positive IOD events tend to force an anomalous anticyclone over the Great Australian Bight, therefore reducing cloud advection across eastern Australia. Positive IOD and central Pacific El Niño also reduce cloud cover over southern and eastern Australia, thus enhancing radiative cooling at night-time. During September 2019, the IOD and central Pacific El Niño were strongly positive, and the observed T_{min} anomalies are well reconstructed based on their historical relationships with the IOD and central Pacific El Niño. This implies that September 2019 T_{min} anomalies should have been predictable at least 1–2 months in advance. However, onset at onset lead time the Bureau of Meteorology ACCESS1.0 seasonal prediction model failed to predict the anomalous anticyclone in the Bight and the wet anomalies in the east. Analysis of hindcasts for 1996–2012 indicates that the model's reconstruction from the IOD and seasonally

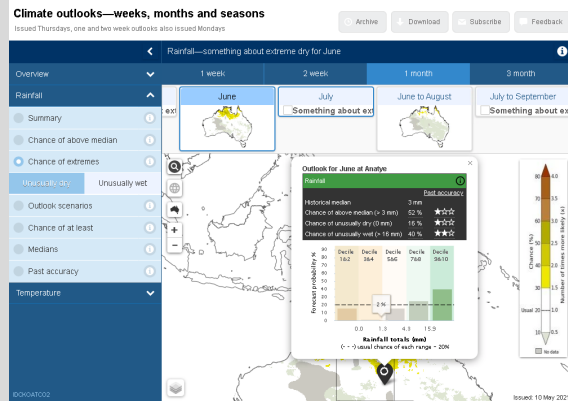
User needs



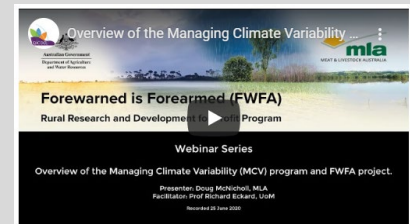
Interfacing to industry decisions



Forecast development and delivery



Extension and training





Developing and delivering new forecasts

FWFA
ACCESS-S1

Forecast
 Hindcast

Forecast Start Date

[Feedback](#)

General Products

- Climate Drivers
 - > Ocean SST indexes
 - > Atmospheric Maps
 - > Probability scenarios
 - > Ocean Maps
- Regions Stations
 - > Climgram with OBS
 - > Climgram
 - > 30 day Meteogram
 - > Pie Charts

FWFA Project

General Products

- > Top bottom decile maps
- > Daily distributions
- > Decile bars
- > Hot & Cold days plume

Heat Extremes

- > Heat wave map
- > Hot days map
- > Mean number of hot days
- > Hot days plume (stations)
- > Temperature-humidity (THI) maps
- > Temperature-humidity (THI) daily distributions (stations)
- > Mean number of THI days
- > THI probability scenarios

Cold Extremes

- > Cold wave map
- > Cold days map
- > Mean number of cold days
- > Cold days plume (stations)
- > Frost potential map
- > Mean number of frost days
- > Chill index (southern livestock)
- > Mean number of Chill index (southern livestock) days

Rain Extremes

- > Number of wet days (select threshold of rainfall amount)
- > Wet spell (longest number of consecutive wet days)
- > Number of dry days
- > Dry spell (longest number of consecutive dry days)
- > Probability of exceedance (stations)
- > Daily Distributions (difference from usual)

Product Characteristics

Variable: Domain: Forecast Period: Output Options:

Number of Hot days (Max T > 90th percentile) Start: 27-Feb-2021
Region: Australia Period: Week: 06-Mar-2021 to 12-Mar-2021

Average number of hot days in the period

Created: 2021-03-01 22:11:38 +0000 Climatology: 1990 to 2012 Resource: access-s1_q5 / w_ens
Source Image: plots/atmos_q5_numhotdaysmap_tasmax/australia/atmos_q5_numhotdaysmap_tasmax_australia_w1_enn_numhotdays_90_20102027_rt.png

- 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

• Feedback from reference groups of users in the dairy, beef, sheep, grains, sugar and wine industries.

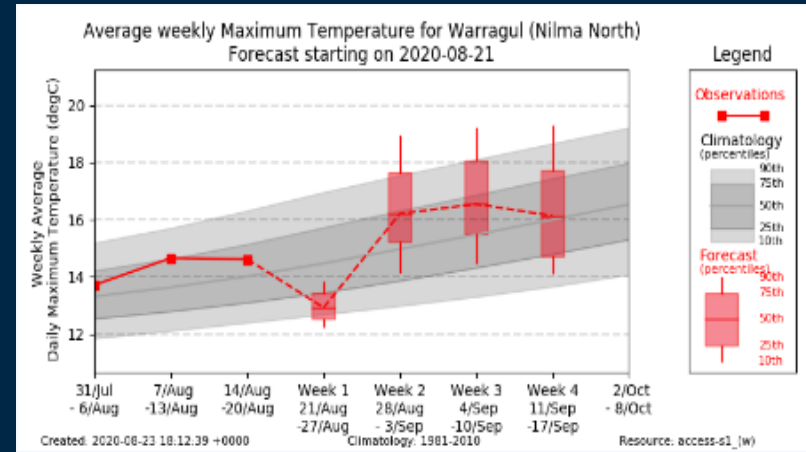
• Deliver five operational products in a staged approach

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
Quirle bars	Interpretation	Can you produce an alternative display of the bars - "trebuchet" or "venetian"?	Feedback from Peter Hayman	October (31/11/18)	Done. Alternative display of the decile bars is available	Look and feel - Do you think this infographic is an appropriate way to look - Is there an alternative display you think would be more so - Do you have suggestions of improvements to the appearance
Quirle bars & pie charts	Look and feel	Remove decimal points (for percentages in quartile)		October (31/11/18)	Done	Interpretation - What does this product tell you? Do you understand what - Is there additional information that could be added to the - Do you find this product confusing? - Do you need more information to understand this product - Do the "explainer images" help you?
Daily distributions	Interpretation	How significant is the skill of the forecast wet climatology?	Feedback from Rob Eckard (and others)	October (31/11/18)		Utility - How might you use this forecast product? (What decisions - Would you use this product in your decision-making? - Are some of the lead times (e.g. multi-week) compared to be in the most useful lead time? What is the largest useful lead? - How informative is it for the risks you face? - Where there circumstances where it helped your decision-
General	Look and feel	Dates with observations in the product images e.g. 2018-01-10 instead of 20180110	Feedback from Rob Eckard	October (13/11/18)	This has been implemented	Other
General	Utility	Add an upcoming (other than calendar) month forecast (e.g. week 1 week)	Feedback from Graeme	October (15/11/18)	We have added weeks 1-4 to the Basic Charts (Atmospheric Maps) in the General Products section to assist evaluating this forecast. One issue which we need to resolve is a potential discrepancy between the Month 1 and Week 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 forecasts are constructed slightly differently. This is a work in progress.	
General	Utility	Can we show a site graph that has last 6 months rainfall (seasonal progress compared to normal) and then adds the excess if ensemble plume for next 3 weeks?	Feedback from Graeme	October (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-S1 in this context given the weather/climate divide, or variability, adding up 7 to not sure 1 each in week, so to get a feel 1+2 week at the moment have to normally add week 1 from 2nd. Good for though. That if week 1 has low skill then don't present it, or present week 1 by itself but with all the usual context of low skill. A number of world agencies have been asked to supply for and we can which one is	John Grey	John Grey (21/11/18)	The current multi-week periods that are displayed operationally (https://www.bom.gov.au/forecast/australia/forecast.html) are week 2, week 3, week 2+3, week 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 forecasts 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).	

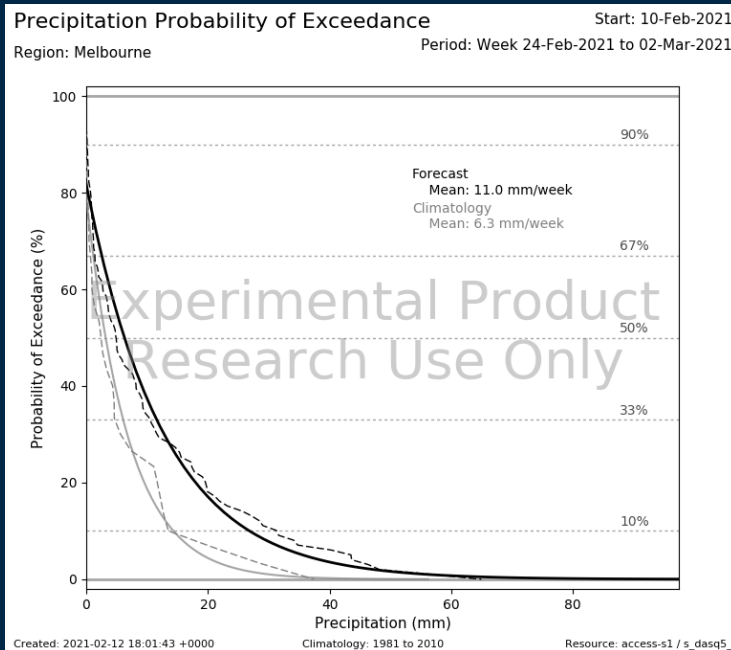


What's next for the products?

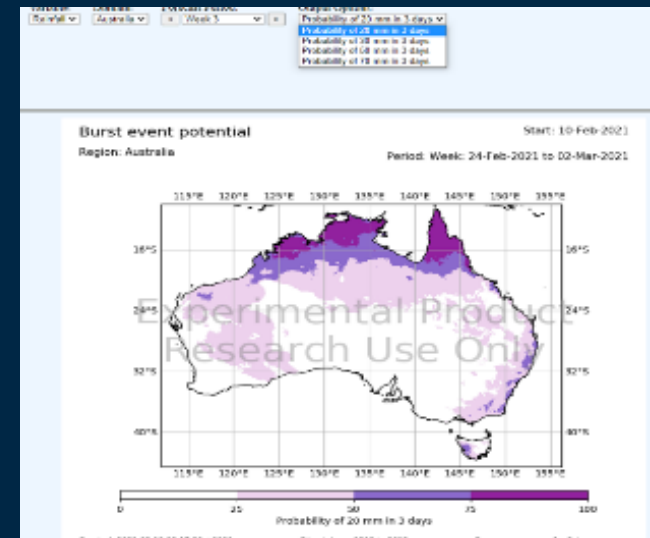
- Product #3 goes live end March 2022. User feedback for proposed operational version underway
- Operational design of products #4, #5 being initiated, going live end May 2022



#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 (3-day accumulations)



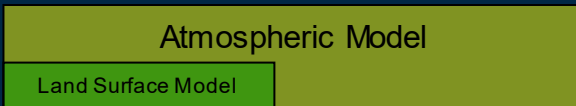
What's next for modelling?

Seamless global coupled modelling

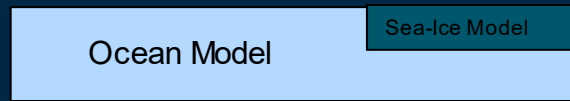
Global weather forecast model

Global ocean forecast model

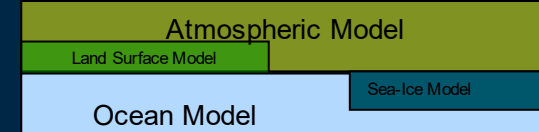
Multi-week/seasonal forecast model



ACCESS-G; ACCESS-GE



OceanMAPS

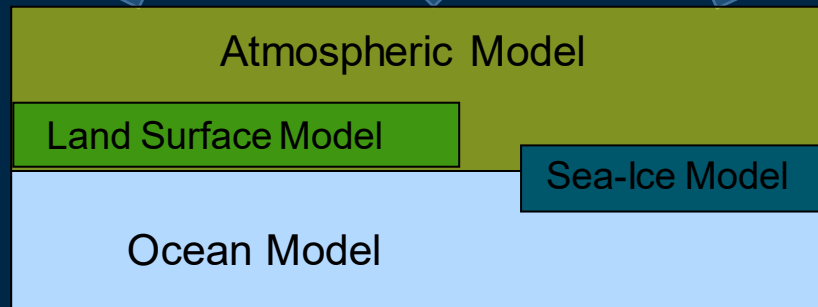


ACCESS-S

NOW

FUTURE

- Seamless and consistent forecasts across timescales and domains (days to seasons; atmosphere and ocean)
- Development (jointly with UKMO) of seamless coupled earth system modelling framework
- Ocean-atmosphere interactions are also important on shorter timescales, for both weather and ocean prediction
- UKMO: operational coupled global NWP forecasts Feb 2022
- BOM starting to investigate coupled NWP and extension into the sub-seasonal



Future global weather, ocean and seasonal forecast model



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WGSIP23 (November 2021)

Thank you

Debbie Hudson

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Research Program

