

**Climate change impacts on potential evapotranspiration, drought,  
and runoff in eastern Australia**

Submitted by

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## **Certificate of Original Authorship**

I, Lijie Shi declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Life Science/Faculty of Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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# Contents

Certificate of Original Authorship .....	
Acknowledgements .....	II
Publications arising from this thesis .....	IV
Contents .....	V
List of Figures .....	VIII
List of Tables .....	XIV
Abbreviations .....	XV
Abstract .....	XVI
Chapter 1. Introduction .....	1
1.1 Brief research background .....	1
1.1.1 Evapotranspiration response to climate change in Australia .....	1
1.1.2 Drought and aridity in Australia .....	1
1.1.3 Water scarcity in Australia .....	3
1.2 Scientific problems and objectives .....	3
1.3 Significance and outline of this thesis .....	4
1.4 Reference .....	7
Chapter 2. Literature review .....	9
2.1 Climate change .....	9
2.1.1 Extreme climate events under a warming climate .....	10
2.1.2 Climate change in Australia .....	11
2.2 Evapotranspiration .....	11
2.2.1 Models used in estimating evapotranspiration .....	13
2.2.2 Response of evapotranspiration to climate change .....	14
2.2.3 Projection of evapotranspiration under future climate scenarios .....	15
2.3 Drought and its response to climate change .....	16
2.3.1 Drought and aridity .....	16
2.3.2 Drought and aridity indices .....	17
2.3.3 Impacts of climate change on drought .....	18
2.4 Runoff and its response to climate change .....	19
2.4.1 Runoff in hydrological cycle and its simulation .....	19
2.4.2 Impacts of climate change on runoff .....	21
2.5 Reference .....	22
Chapter 3. Performance of potential evapotranspiration models across different climatic zones in New South Wales, Australia .....	31
3.1 Introduction .....	31
3.2 Study area and climate datasets .....	35
3.3 Estimation of potential evapotranspiration .....	38
3.3.1 Penman model .....	38
3.3.2 Temperature-based ETp models .....	40
3.3.3 Radiation-based ETp models .....	41

3.3.4 Mass transfer-based ETp models .....	42
3.4 Models' performance in estimating ETp rates .....	42
3.5 Models' ability in capturing ETp dynamics and periodic oscillations .....	43
3.6 Results .....	45
3.6.1 Performance of models in estimating ETp rates .....	45
3.6.2 Ability of alternative models in capturing the dynamics of ETp .....	51
3.6.3 Ability of alternative models to analyze the periodicity in ETp .....	54
3.7 Discussion .....	55
3.8 Conclusions .....	57
3.9 Reference .....	59
Chapter 4. Projecting potential evapotranspiration change and quantifying its uncertainty under future climate scenarios: A case study in southeastern Australia .....	65
4.1 Introduction .....	66
4.2 Study area .....	69
4.3 Climate data and downscaling method applied .....	71
4.4 Empirical ETp models and random forest-based ETp models .....	74
4.5 Model evaluation .....	77
4.6 Future ETp projection .....	78
4.8 Results .....	78
4.8.1 Performance of ETp models during the historical period .....	78
4.8.2 The change of climatic factors under future climate scenarios .....	80
4.8.3 ETp and its change under future climate scenarios .....	84
4.8.4 Contribution of climatic factors to ETp change .....	86
4.8.5 Contribution of different sources to the uncertainty of ETp projections .....	87
4.9 Discussion .....	88
4.10 Conclusions .....	91
4.11 Reference .....	92
Chapter 5. Quantifying future drought change and associated uncertainty in southeastern Australia with multiple potential evapotranspiration models .....	97
5.1 Introduction .....	98
5.2 Study sites .....	101
5.3 Climatic data .....	103
5.4 Calculation of potential evapotranspiration .....	105
5.5 Calculation of standardized precipitation evapotranspiration index .....	106
5.6 Contribution analysis of uncertainty in future drought projection .....	108
5.7 Results .....	108
5.7.1 Droughts occurring in the historical period .....	108
5.7.2 Projected changes of climatic factors under future scenarios .....	110
5.7.3 Projected changes of potential evapotranspiration under future climate scenarios .....	112
5.7.4 Projected changes in drought frequency and their relationship with climatic factors .....	114
5.7.5 Uncertainty analysis in drought projection .....	119
5.8 Discussion .....	120
5.9 Conclusions .....	124
5.10 Reference .....	125

Chapter 6. Subtle difference observed in runoff projection with different potential evapotranspiration inputs based on Xinanjiang model.....	131
6.1 Introduction.....	132
6.2 Materials and methods .....	135
6.2.1 Study area .....	135
6.2.2 Xinanjiang (XAJ) model.....	136
6.2.3 Climate data and observed runoff.....	138
6.2.4 The remote sensing-based evapotranspiration product and empirical ETp models .....	139
6.2.5 Calibration and validation of XAJ model .....	140
6.2.6 Evaluation of model performance.....	140
6.2.7 Partitioning uncertainty to different sources .....	141
6.3 Results.....	141
6.3.1 ETp calculated with empirical models PML_V2.....	141
6.3.2 XAJ model calibration and cross-model validation.....	142
6.3.3 Changes in rainfall and evapotranspiration under future climate scenarios.....	146
6.3.4 Changes in soil moisture under future climate scenarios .....	148
6.3.5 Changes in runoff under future climate scenarios at different time scales.....	149
6.3.6 Uncertainty in runoff projection.....	151
6.4 Discussion .....	152
6.5 Conclusion .....	154
6.6 Reference.....	155
Chapter 7. Summary and future research.....	160
7.1 Summary .....	160
7.2 Limitations and future research.....	162
7.3 Reference.....	163



## List of Figures

- Figure 1-1. Examples of damage caused by major drought happened in Australia. The figure is extracted from Mpelasoka et al. (2008) ..... 2
- Figure 1-2. Flow chart of this project ..... 6
- Figure 3-1 The distribution of 2120 stations and the division of climate zones in NSW based on the aridity index (rainfall/potential evapotranspiration). ..... 36
- Figure 3-2 Scatter plot with daily ETp from 1970 to 2014 at eight stations belonging to arid (Tibooburra & Wilcannia), semi-arid (Cobar & Gunnedah), sub-humid (Murrurundi & Paterson), and humid (Coffs Harbour & Sydney) zones. ETp\_observed (mm day<sup>-1</sup>) represents daily ETp estimated with Penman, WMO, Mahringer (Mah), and Trabert (Tra) based on observed wind speed whereas ETp\_2m/s (mm day<sup>-1</sup>) represents daily ETp estimated with the corresponding models (Penman2, WMO2, Mah2, and Tra2) based on the recommended wind speed, 2 m s<sup>-1</sup>. The red line is the 1:1 line. .... 38
- Figure 3-3 Scatter plot between annual ETp estimated by Penman model (ET-Penman, mm year<sup>-1</sup>) and ET0 estimate by Penman-FAO56 (ET-FAO56, mm year<sup>-1</sup>) at four climate zones from 1970 to 2014. .... 39
- Figure 3-4 Models' ability in estimating daily ETp, shown by Taylor diagram. Taylor diagram displayed the performance of 12 ETp models in terms of amplitude of their variations (the radial distance from the origin the points was proportional to the pattern standard deviations) and their correlation coefficients (given by the azimuthal position of the test field) against Penman-calculated ETp. The dark red lines represented the skill scores. The data used to plot the Taylor diagrams was the averaged daily ETp for each climate zone from 1970 to 2014. The X-axis and Y-axis both represented standard deviations (SDs) of ETp. The column of S in this figure was daily Taylor skill score for each model. .... 46
- Figure 3-5 The distribution of nRMSE (%) between daily ETp estimated by simplified ETp models and ETp estimated by Penman model from 1970 to 2014. Data used for each climate zone is the daily nRMSE of stations locating in this zone, that is, 201 stations for arid zone, 980 stations for semi-arid zone, 536 stations for sub-humid zone, and 403 stations for humid zone. The upper and lower box boundaries indicate the 75th and 25th percentiles; the black line and the black dot within the box represents the median and mean value, respectively; the upper and lower whiskers are the 10th and 90th percentiles. The hollow boxes represented for the radiation-based models. The red boxes were for temperature-based models and the purple boxes represented for the mass transfer-based models. .... 47
- Figure 3-6 Distribution of rMBE (%) between daily ETp estimated by simplified ETp models and ETp estimated by Penman model from 1970 to 2014. Data used for each climate zone is the daily rMBE (%) of stations locating in this zone, that is, 201 stations for arid zone, 980 stations for semi-arid zone, 536 stations for sub-humid zone, and 403 stations for humid zone. The upper and lower box boundaries indicate the 75<sup>th</sup> and 25<sup>th</sup> percentiles; the black line and the black dot within the box represents the median and mean value, respectively; the upper and lower whiskers are the 10th and 90th percentiles. The hollow boxes represented for the radiation-based models. The red boxes were for temperature-based models and the purple boxes represented for the mass transfer-based models. .... 48
- Figure 3-7 Models' ability in estimating seasonal ETp, shown by Taylor diagram. The data used to plot

the Taylor diagrams was the averaged seasonal ETp for each climate zone from 1970 to 2014. The column of S in this figure was seasonal Taylor skill scores for each model. Other explanations of Taylor diagram were the same with Figure 3-4. .... 49

Figure 3-8 The distribution of nRMSE (%) between seasonal ETp estimated by simplified ETp models and ETp estimated by Penman model from 1970 to 2014. Data used for each climate zone is the seasonal nRMSE of stations locating in this zone, that is, 201 stations for arid zone, 980 stations for semi-arid zone, 536 stations for sub-humid zone, and 403 stations for humid zone. The explanation of boxes was the same with that in Figure 3-5. .... 50

Figure 3-9 Distribution of rMBE (%) between seasonal ETp estimated by simplified ETp models and ETp estimated by Penman model from 1970 to 2014. Data used for each climate zone is the seasonal rMBE (%) of stations locating in this zone, that is, 201 stations for arid zone, 980 stations for semi-arid zone, 536 stations for sub-humid zone, and 403 stations for humid zone. The explanation of boxes was the same with that in Figure 3-5. .... 51

Figure 3-10 Temporal evolution of ETp estimated by 13 models from 1970 to 2014 for each climate zone. .... 52

Figure 3-11 The temporal trends of precipitation both for seasonal and annual scales at four climate zones in the research period from 1970 to 2014. .... 53

Figure 3-12 The temporal trends of annual ETp (mm year<sup>-1</sup>) estimated by 13 models at four climate zones in the research period from 1970 to 2014. The asterisk symbol (\*) showed the significant level. \*: significant at 95% confidence level; \*\*: significant at 99% confidence level. .... 53

Figure 3-13 The temporal trends of seasonal ETp (mm year<sup>-1</sup>) estimated by 13 models at four climate zones in the research period from 1970 to 2014. The asterisk symbol (\*) had the same meaning with that in Figure 3-12. .... 54

Figure 3-14 The wavelet-spectra and variances of annual ETp estimated by 13 models at four climate zones. The thin solid lines denote the cones of influence, and the thick solid lines show the 95% confidence levels. The colour bar means the vibration intensity of the periods at different timescales. .... 55

Figure 4-1 The location of eight stations in four different climate zones across New South Wales, Australia, and their elevations (m) determined by digital elevation model (DEM). The climate dividing lines have the same meaning with that in Figure 3-1 and is developed based on the widely used aridity index (rainfall/ETp) (UNESCO, 1979)..... 70

Figure 4-2 Flow diagram of the random forest model. .... 76

Figure 4-3 The average annual ETp (mm year<sup>-1</sup>) calculated by eight ETp models for each station during the model testing period (2001 - 2014). The dashed lines and red bars indicate the average annual ETp calculated by the Penman-Monteith model. .... 79

Figure 4-4. Scatter plots of the Penman-calculated daily ETp (mm day<sup>-1</sup>) vs ETp calculated by RF-based and empirical ETp models during the model testing stage (2001 - 2014) for each of eight stations in New South Wales, Australia. The units for RMSE and rMBE are mm day<sup>-1</sup> and %, respectively. Blue lines are linear regression lines and red lines are 1:1 lines..... 80

Figure 4-5. Projected changes in Tmax (°C), Tmin (°C), and Tmax-Tmin (°C) in the near future (2026 – 2050, 2040s), the medium future (2051 – 2075, 2065s), and the far future (2076 – 2100, 2090s) at eight stations in New South Wales, Australia, under RCP4.5 and RCP8.5 scenarios based on 34 GCMs compared with baseline values (1990 - 2014). Lower and upper box boundaries indicate the 25th and 75th percentiles, respectively. The black lines and dots inside the box mark the median

and mean, respectively. The lower and upper whiskers indicate the 10th and 90th percentiles, respectively.....	82
Figure 4-6. Projected changes in Rs ( $\text{MJ m}^{-2} \text{ day}^{-1}$ ), and rainfall ( $\text{mm year}^{-1}$ ) in the near future (2026 – 2050, 2040s), the medium future (2051 – 2075, 2065s), and the far future (2076 – 2100, 2090s) at eight stations in New South Wales, Australia, under RCP4.5 and RCP8.5 scenarios based on 34 GCMs compared with baseline values (1990 - 2014). Lower and upper box boundaries indicate the 25th and 75th percentiles, respectively. The black lines and dots inside the box mark the median and mean, respectively. The lower and upper whiskers indicate the 10th and 90th percentiles, respectively.....	83
Figure 4-7. Projected ETp changes for eight stations in New South Wales, Australia in the near future (2026 - 2050, 2040s), the medium future (2051 - 2075, 2065s), and the far future (2076 - 2100, 2090s) under RCP4.5 and RCP8.5 scenarios based on 34 GCMs compared with baseline ETp (1990 - 2014). Lower and upper box boundaries indicate the 25th and 75th percentiles, respectively. The black lines and dots inside the box mark the median and mean, respectively. The lower and upper whiskers indicate the 10th and 90th percentiles, respectively. ....	85
Figure 4-8 25-year averaged annual ETp ( $\text{mm year}^{-1}$ ) at eight stations for the near future (2026 – 2050, 2040s), the medium future (2051 – 2075, 2065s), and the far future (2076 – 2100, 2090s) under RCP4.5 and RCP8.5. Box boundaries indicate the 25th and 75th percentiles; the black lines and dots inside the box mark the median and mean, respectively; the lower and upper whiskers indicate the 10th and 90th percentiles, respectively. ....	85
Figure 4-9 Regression coefficients for changes in ETp ( $\Delta\text{ETp}$ , $\text{mm year}^{-1}$ ) with changes in maximum temperature ( $\Delta\text{Tmax}$ , $^{\circ}\text{C}$ ), minimum temperature ( $\Delta\text{Tmin}$ , $^{\circ}\text{C}$ ), solar radiation ( $\Delta\text{Rs}$ , $\text{MJ m}^{-2} \text{ day}^{-1}$ ), and rainfall ( $\Delta\text{P}$ , $\text{mm year}^{-1}$ ) in a multiple liner regression model ( $\Delta\text{ETp} = a \Delta\text{Tmax} + b \Delta\text{Tmin} + c \Delta\text{Rs} + d \Delta\text{P}$ ); units for a and b are $\text{mm year}^{-1} \text{ }^{\circ}\text{C}^{-1}$ ; units for c are $\text{mm year}^{-1} (\text{MJ m}^{-2} \text{ d}^{-1})^{-1}$ ; units for d are $\text{mm year}^{-1} \text{ mm}^{-1}$ . ***:p < 0.001, **:p < 0.01; *:p < 0.05 .....	87
Figure 4-10. The contribution of uncertainty sources to the change of ETp.....	88
Figure 5-1 Location of the two study sites in the wheat belt of New South Wales (NSW), Australia.	102
Figure 5-2 The qq-plots between simulated SPEI driven by downscaled climatic data from 34 GCMs and observed SPEI driven by observed climatic data from SILO at Gunnedah (the upper panels, a) and Wagga Wagga (the bottom panels, b) under RCP4.5 (left panels) and RCP8.5 (right panels) scenarios. RF1, RF2, and RF3 (random forest models 1, 2, and 3, respectively); JH (Jensen-Haise); Mak (Makkink); HS (Hargreaves); Ab (Abteu). Abbreviations above the individual panels refer to specific GCMs. ....	104
Figure 5-3 Frequency of seasonal droughts occurring in the period from 1971 to 2010 at Gunnedah and Wagga Wagga, Australia, using eight potential evapotranspiration models. RF1, RF2, and RF3 (random forest models 1, 2, and 3, respectively); JH (Jensen-Haise); Mak (Makkink); HS (Hargreaves); Ab (Abteu). Mild, moderate, and severe drought classifications are based on Standardized Precipitation Evapotranspiration Index values as described in section 5.5. Drought refers to the total of all drought classifications. ....	109
Figure 5-4 Mean seasonal potential evapotranspiration (ETp, $\text{mm year}^{-1}$ ) from 1971 to 2010 at Gunnedah and Wagga Wagga, Australia calculated by eight ETp models. RF1, RF2, and RF3 (random forest models 1, 2, and 3, respectively); JH (Jensen-Haise); Mak (Makkink); HS (Hargreaves); Ab (Abteu).....	110
Figure 5-5 Projected changes in maximum (Tmax, $^{\circ}\text{C}$ , a1, a2) and minimum (Tmin, $^{\circ}\text{C}$ , b1, b2) air	

temperature, solar radiation ( $R_s$ ,  $\text{MJ m}^{-2} \text{ day}^{-1}$ , c1, c2), and precipitation (P, %, d1, d2) in the 2040s and 2080s at Gunnedah (a1, b1, c1, d1) and Wagga Wagga (a2, b2, c2, d2), Australia, under RCP4.5 and RCP8.5 scenarios. Lower and upper box boundaries indicate the 25th and 75th percentiles, respectively. The black line and dot inside each box indicate the median and mean, respectively. The lower and upper whiskers indicate the 10th and 90th percentiles, respectively.....111

Figure 5-6 Projected changes in potential evapotranspiration (ETp, %) in the near future (2021-2060, 2040s) and further future (2061-2100, 2080s) at Gunnedah and Wagga Wagga, Australia, under RCP4.5 and RCP8.5 scenarios based on 34 GCMs compared with baseline values (1971-2010). Lower and upper box boundaries indicate the 25th and 75th percentiles, respectively. The black line and dot inside each box mark the median and mean, respectively. The lower and upper whiskers indicate the 10th and 90th percentiles, respectively..... 113

Figure 5-7 Regression coefficients for changes in ETp ( $\Delta\text{ETp}$ , %) at Gunnedah and Wagga Wagga, southeast Australia, with changes in Tmax ( $\Delta\text{Tmax}$ , °C), Tmin ( $\Delta\text{Tmin}$ , °C), and Rs ( $\Delta\text{Rs}$ ,  $\text{MJ m}^{-2} \text{ day}^{-1}$ ) in a multiple liner regression model ( $\Delta\text{ETp}$  (%) =  $a_0 \cdot \Delta\text{Tmax}$  (°C) +  $b_0 \cdot \Delta\text{Tmin}$  (°C) +  $c_0 \cdot \Delta\text{Rs}$  ( $\text{MJ m}^{-2} \text{ day}^{-1}$ )) for seven ETp models; \*\*\*:p < 0.001, \*\*:p < 0.01; \*:p < 0.05. RF1, RF2, and RF3 (random forest models 1, 2, and 3, respectively); JH (Jensen-Haise); Mak (Makkink); HS (Hargreaves); Ab (Abtew). Units for a0 and b0 are % °C<sup>-1</sup>; units for c0 are % ( $\text{MJ m}^{-2} \text{ day}^{-1}$ )<sup>-1</sup>. The color legend represents the values of a0, b0, and c0..... 114

Figure 5-8 Changes in the frequency of seasonal mild drought (upper left panels,  $-1 < \text{SPEI} \leq -0.5$ ), moderate drought (upper right panels,  $-1.5 < \text{SPEI} \leq -1$ ), severe drought (lower left panels,  $\text{SPEI} \leq -1.5$ ), and the total drought ( $\text{SPEI} \leq -0.5$ ) in the near (2021 – 2060, 2040s) and further (2061 – 2100, 2080s) future periods compared with the baseline period (1971 - 2010) at Gunnedah and Wagga Wagga, Australia. The calculation of SPEI was based on seven ETp models driven by downscaled climatic data from 34 GCMs under RCP4.5 and RCP8.5 scenarios. Data presented are changed mean frequency in the 40-year values for the 34 GCMs compared with that of the baseline period. RF1, RF2, and RF3 (random forest models 1, 2, and 3, respectively); JH (Jensen-Haise); Mak (Makkink); HS (Hargreaves); Ab (Abtew)..... 116

Figure 5-9 Changes in the frequency of seasonal mild drought (upper left panels,  $-1 < \text{SPEI} \leq -0.5$ ), moderate drought (upper right panels,  $-1.5 < \text{SPEI} \leq -1$ ), severe drought (lower left panels,  $\text{SPEI} \leq -1.5$ ), and the total drought (lower right panels,  $\text{SPEI} \leq -0.5$ ) in the near (2021-2060, 2040s) and further (2061 – 2100, 2080s) future periods compared with the baseline period (1971 - 2100) at Gunnedah and Wagga, Australia. The calculation of SPEI was based on seven ETp models driven by downscaled climatic data from 34 GCMs under RCP4.5 and RCP8.5 scenarios. Data presented are changed frequency in the 40-year values for each of the 34 GCMs compared with that of the baseline period. Lower and upper box boundaries indicate the 25th and 75th percentiles, respectively. The black line and dot inside each box mark the median and mean, respectively. The lower and upper whiskers indicate the 10th and 90th percentiles, respectively. RF1, RF2, and RF3 (random forest models 1, 2, and 3, respectively); JH (Jensen-Haise); Mak (Makkink); HS (Hargreaves); Ab (Abtew). RF1, RF2, and RF3 (random forest models 1, 2, and 3, respectively); JH (Jensen-Haise); Mak (Makkink); HS (Hargreaves); Ab (Abtew)..... 117

Figure 5-10 Regression coefficients for changes in frequency of seasonal droughts ( $\Delta\text{F}$ , %) at Gunnedah and Wagga Wagga, Australia with changes in precipitation ( $\Delta\text{P}$ , %) and potential evapotranspiration ( $\Delta\text{ETp}$ , %) in a multiple liner regression model ( $\Delta\text{F}$  (%) =  $a \cdot \Delta\text{P}$  (%) +  $b \cdot \Delta\text{ETp}$  (%)) for seven ETp models; \*\*\*:p < 0.001, \*\*:p < 0.01; \*:p < 0.05. RF1, RF2, and RF3 (random forest models 1, 2,

and 3, respectively); JH (Jensen-Haise); Mak (Makkink); HS (Hargreaves); Ab (Abtew). Coefficients a and b are dimensionless. The color legend represents the values of a and b..... 118

Figure 5-11 Contribution (%) of GCMs, RCPs, and ETp models to the uncertainty in drought frequency projection at Gunnedah and Wagga Wagga, Australia for each season. Results for mild, moderate, and severe drought are shown from inward to outward circles, respectively. Contributions larger than 15% are shown by numbers in the figure. .... 120

Figure 6-1 Location of the North Johnstone River catchment, Queensland, Australia and the distribution of 10 weather stations and the location of Tung Oil gauge (a hydrologic gauge station). .... 135

Figure 6-2 The flow chart for the XAJ model. .... 137

Figure 6-3 Scatter plots of the daily ETa (mm day<sup>-1</sup>) estimated by PML\_V2 vs ETp estimated by empirical ETp models from 2000 to 2017 for each of ten stations in North Johnstone river catchment, Queensland, Australia. The units for RMSE is mm day<sup>-1</sup>. The red and the blue lines represent the 1:1 lines and the linear regression lines, respectively. .... 142

Figure 6-4 The observed daily runoff and the simulated daily runoff by XAJ model with calibrated parameters of Ab model (as in Table 6-1) during calibration (2000-2010) and validation (2011-2017) periods in the North Johnstone catchment. .... 145

Figure 6-5 The annual historical observed and simulated runoffs with calibrated parameters shown in Table 1 in the North Johnstone river basin. The bar plot (second-y-axis) showed the bias error (simulated runoff-observed runoff)/observed runoff\*100) between simulated runoff and observed runoff. .... 146

Figure 6-6 Projected seasonal changes in rainfall (%) in the near future (2021-2040, 2030s), middle future (2041-2060, 2050s), far future (2061-2080, 2070s), and further future (2081-2100, 2090s) under RCP4.5 and RCP8.5 scenarios based on 34 GCMs compared with the baseline period (2001-2020). The upper and lower box boundaries indicate the 75th and 25th percentiles; the black line and the black dot within the box represents the median and mean value, respectively; the upper and lower whiskers are the 10th and 90th percentiles. .... 147

Figure 6-7 Projected seasonal changes in ETp (%) and ETa (%) for different ETp models in the near future (2021-2040, 2030s), middle future (2041-2060, 2050s), far future (2061-2080, 2070s), and further future (2081-2100, 2090s) under RCP4.5 and RCP8.5 scenarios based on 34 GCMs compared with the baseline period (2001-2020). The upper and lower box boundaries indicate the 75th and 25th percentiles; the black line and the black dot within the box represents the median and mean value, respectively; the upper and lower whiskers are the 10th and 90th percentiles. .... 148

Figure 6-8 Projected seasonal changes in soil moisture for different layers, namely the upper soil layer (0 - 20 cm), the lower soil layer (20 – 50 cm), and the deepest soil layer (> 50 cm) in the near future (2021-2040, 2030s), middle future (2041-2060, 2050s), far future (2061-2080, 2070s), and further future (2081-2100, 2090s) under RCP4.5 and RCP8.5 scenarios based on 34 GCMs compared with the baseline period (2001-2020). The upper and lower box boundaries indicate the 75th and 25th percentiles; the black line and the black dot within the box represents the median and mean value, respectively; the upper and lower whiskers are the 10th and 90th percentiles. .... 149

Figure 6-9 Projected seasonal changes in runoff (%) for different ETp models in the near future (2021-2040, 2030s), middle future (2041-2060, 2050s), far future (2061-2080, 2070s), and further future (2081-2100, 2090s) under RCP4.5 and RCP8.5 scenarios based on 34 GCMs compared with the baseline period (2001-2020). The upper and lower box boundaries indicate the 75th and 25th percentiles; the black line and the black dot within the box represents the median and mean value,

respectively; the upper and lower whiskers are the 10th and 90th percentiles ..... 150

Figure 6-10 Pearson correlation coefficients for the relation between runoff and its related factors. The purple color showed negative correlation while the red color showed the positive correlation. . 151

Figure 6-11 The relative contribution of GCMs, RCPs, ETp models and their interactions to the uncertainty caused in runoff projection for each season. .... 152

## List of Tables

Table 3-1. The mean minimum (Tmin) and maximum (Tmax) air temperature, solar radiation (Rs), relative humidity (RH), rainfall (P), potential evapotranspiration (ETp), and aridity index (AI) in the study period from 1970 to 2014.....	36
Table 4-1 Geographical and long-term average meteorological information for eight stations locating in for different climate zones across New South Wales, Australia. The values in parentheses are the standard deviations for each variable .....	71
Table 4-2 Identifying information for 34 global climate models (GCMs). GCMs were used for statistically downscaling outputs for eight stations across New South Wales, Australia, under the RCP4.5 and RCP8.5 scenarios.....	73
Table 4-3. The input requirements of seven ETp models used in this study. ....	77
Table 5-1 Geographical and long-term averaged meteorological information for Gunnedah and Wagga Wagga, Australia. The geographical information includes longitude (Lon), latitude (Lat), and elevation (DEM). The meteorological information includes air temperature (T), solar radiation (Rs), relative humidity (RH), wind speed (Wind), precipitation (P), and potential evapotranspiration (ETp).....	103
Table 5-2 Potential evapotranspiration (ETp) models used in this study. The Penman model was used as the benchmark to develop and train the RF-based models and to assess the performance of the RF-based and the empirical ETp models. ETp estimated by the four empirical ETp models was compared with ETp estimated by the RF-based models which required the same inputs. Specifically, JH and Mak were compared with RF1; HS was compared with RF2; and Ab was compared with RF3.....	105
Table 5-3 Variance inflation factors (VIF) to choose independent factors for multiple linear regression. ....	118
Table 6-1 Geographical and the multi-year (2001-2017) mean meteorological information in the research period for ten stations in North Johnstone catchment.....	136
Table 6-2 The 16 calibrated parameters and their value that were good for all ETp models to produce the best runoff simulation in the North Johnstone river catchment. The values of parameters were the results of cross-model validation.....	138
Table 6-3 Group of parameters calibrated with ETp estimated by different models to drive XAJ model. ....	143
Table 6-4 The R <sup>2</sup> , NSE, and RMSE between observed runoff and simulated runoff with the six groups of parameters shown in Table 6-3. The ETp model that was used to calibrated XAJ model was marked as red during cross-model validation. The unit for RMSE is mm day <sup>-1</sup> . ....	144

## Abbreviations

BoM	Bureau of Meteorology
CR	Capillary rise
DP	Deep percolation
ET	Evapotranspiration
ETa	Actual evapotranspiration
ETp	Potential evapotranspiration
ET0	Reference evapotranspiration
H	Sensible heat of water
I	Irrigation water
G	Soil heat flux
GCMs	Global Climate Models
P	Precipitation
XAJ	Xinjiang model
RCPs	Representative Concentration Pathways
Rn	Net radiation
RO	Runoff
R	Surface runoff
SILO	Science
SPEI	Standardized precipitation evapotranspiration index
$\lambda$	Latent heat of vaporization
$\Delta$ SF	Horizontal surface flow
$\Delta$ SW	Change in soil moisture



## Abstract

As one of the most arid continents, Australia is exposed to drought and water scarcity. The changing climate is likely to intrigue more drought occurrence and make water scarcity more severe. In this context, it is important to investigate the influence of climate change on drought and water availability in Australia.

This study aimed to investigate the possible change of potential evapotranspiration (ET<sub>p</sub>), drought occurrence, and runoff under future climate scenarios, thus providing useful information to mitigate the adverse impacts of climate change on crop production and water resource management. In specific, four inter-related studies were carried out based on widely used empirical ET<sub>p</sub> models, random forest method, statistical indices, standardized precipitation evapotranspiration index (SPEI), Xinanjiang model, and a three-way analysis of variance. Findings from these studies suggested that: (1) radiation based models including Jensen-Haise, Abtew, modified Makkink, and Turc and temperature-based model Hargreaves were able to reasonably estimate ET<sub>p</sub> rates, capture its temporal evolution, and periodically oscillation; (2) random forest-based ET<sub>p</sub> models generally outperformed empirical ET<sub>p</sub> models which required the same climatic inputs; (2) ET<sub>p</sub> was likely to increase in the future and the increase could be mostly explained by the increase in temperature and solar radiation; (3) Droughts, especially for moderate and severe droughts were also likely to increase and the increases in spring and winter were larger than that in summer and autumn. The increase in ET<sub>p</sub> explained more of the change in drought than the decrease in rainfall did; (4) There were obvious decreases in spring and winter runoff whereas the mean changes in summer and autumn runoff were subtle. The changes in runoff were consistent with the pattern of changes in rainfall and the difference in ET<sub>p</sub> inputs barely influenced runoff projection; (5) GCMs, RCPs, or their interaction generally were the dominant factors resulting in uncertainty in the projections of ET<sub>p</sub>, drought, and runoff in future climate scenarios.

This study confirmed the increase in air evaporative demand, drought occurrence, and water scarcity in eastern Australia and highlighted the necessary to for farmers and policy makers take measures to adapt to the changing climate. The possible measures include cultivating drought-resistant varieties, adjusting the planting structure, improving the capability of drought forecast, and changing the seeding windows accordingly.

**Keywords:** climate change; potential evapotranspiration; random forest, drought; runoff; uncertainty; eastern Australia