THE AUSTRALIAN NATIONAL UNIVERSITY

Making the Most of Ground Based Meteorological Network Using Anomaly Based Interpolation

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Contents

- Anomaly based interpolation well established
- Background fields for standard period (1976-2005) can be interpolated from all available data – incorporating fine scale topographic controls - to significantly extend the supporting data network
- Effects of proximity to the coast on temperature can be optimised
- New anomaly process for daily and monthly rainfall
- Robustly determined broad scale anomalies for all variables – error detection and correction – improved prediction accuracy – additional predictors
- Assessment of network quality

Background

High resolution climate interpolation methodology has been developed for wide applications including

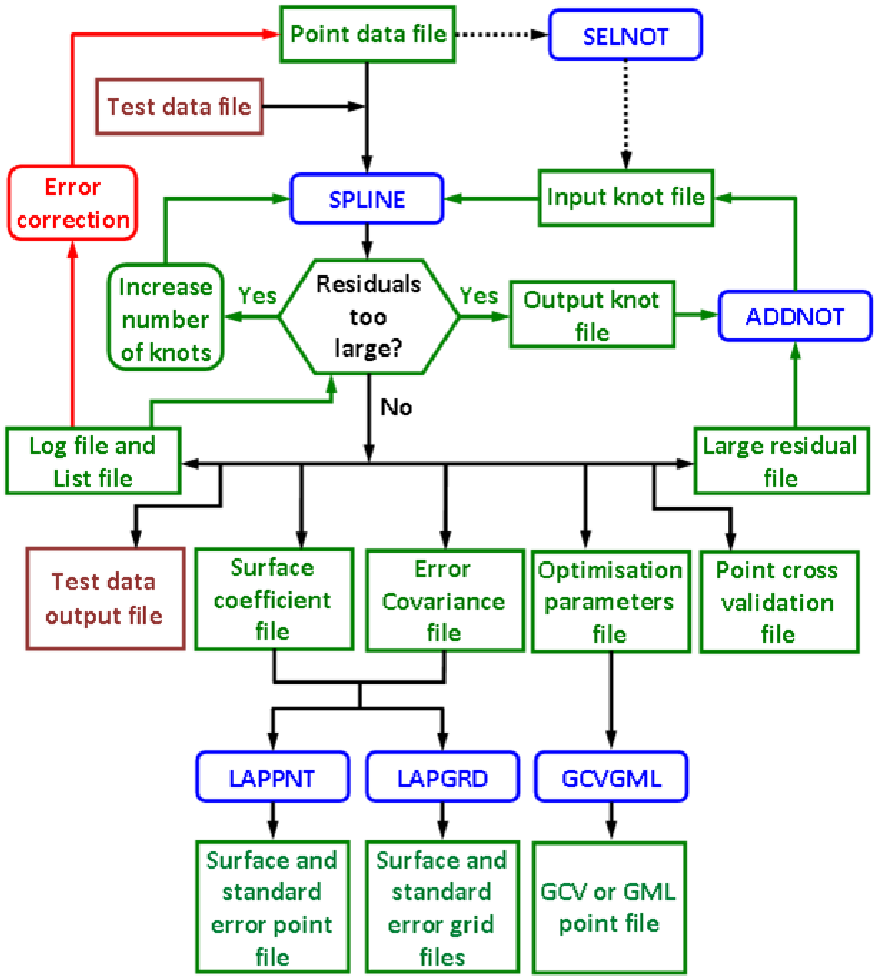
Ongoing support of FullCAM for Department of Environment

eMAST TERN facility –
ENABLE benchmarking, evaluation, optimization of ecosystem models
SUPPORT ecosystem science, impact assessment and management

Bureau of Meteorology, Environment Canada

Many others

Flowchart for ANUSPLIN Version 4.4



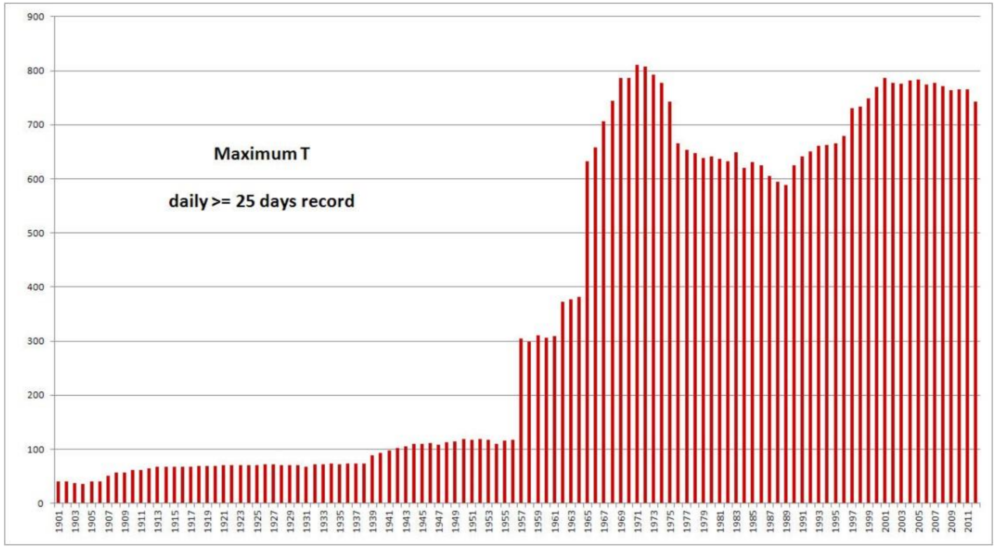
ANUClimate data sets (1 km resolution)

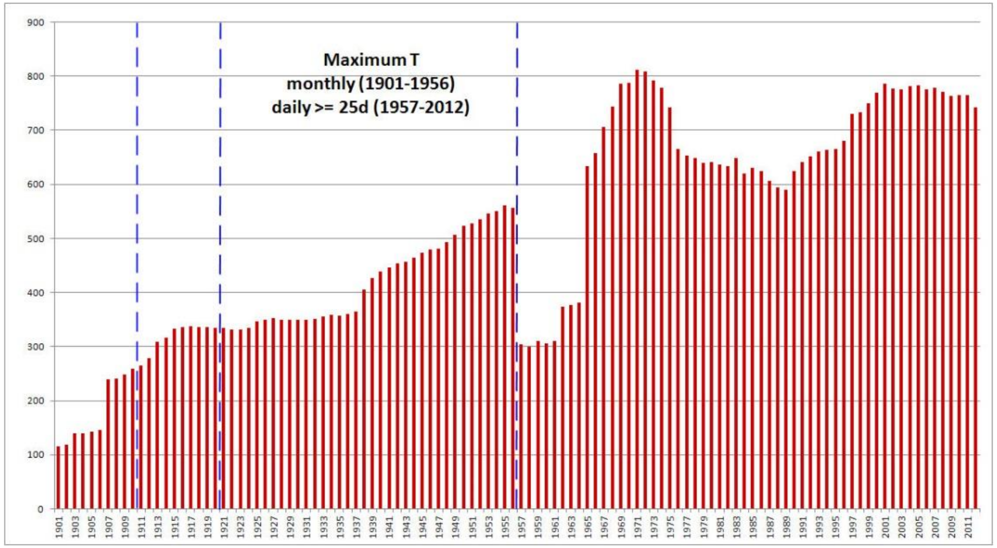
	Tmin	Tmax	Vap Press	Precip	Pan Evap	Wet days	Solar Rad	Model Runoff
daily 1970-2011	✓	✓	✓	✓				
monthly 1970-2011	✓	✓	✓	✓	✓	✓	✓	✓
monthly mean	✓	✓		✓	✓	✓	✓	

TERN
Terrestrial Ecosystem Research Network

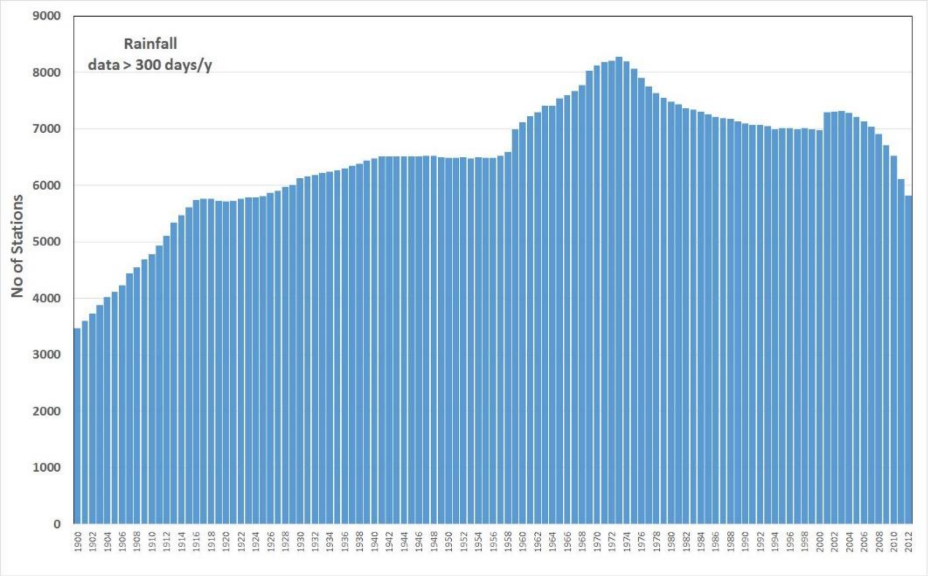
e-MAST
Ecosystem Modelling & Scaling Infrastructure

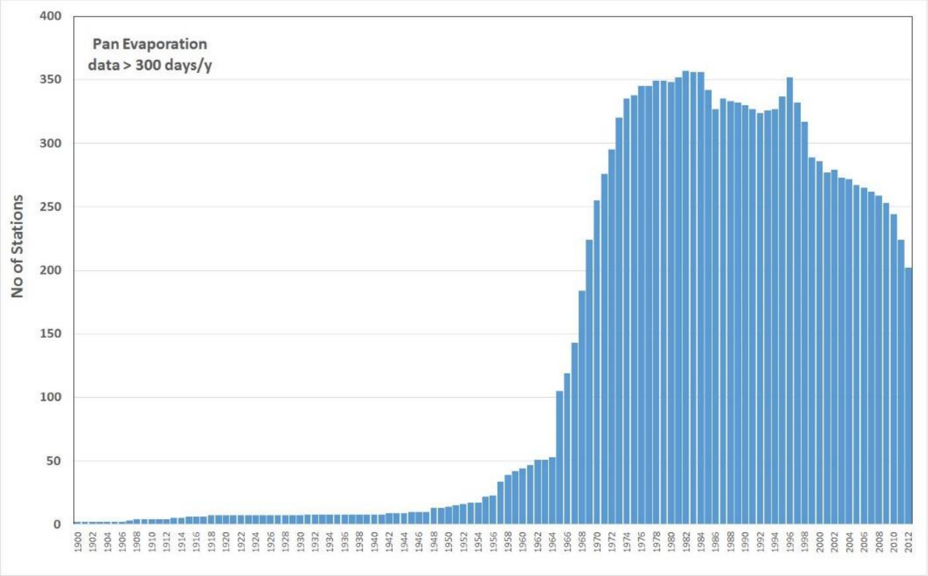
Temporal Coverage of Daily Maximum Temperature Data





Temporal Coverage of Rainfall and Pan Evaporation Data





Standardisation of short period maximum temperature records to 1976-2005 means

N_o = number of years observed

N_{oo} = number of years observed between 1976 and 2005

N_r = number of years estimated by regression with a long term station

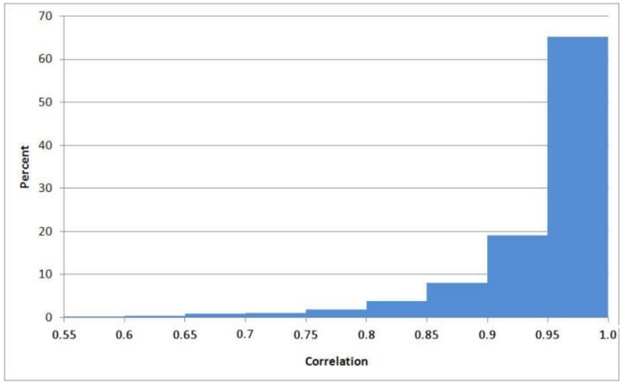
$N = N_{oo} + N_r$ (N_{oo} can be 0)

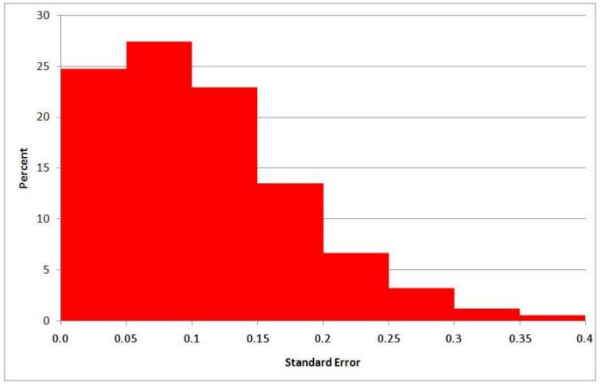
Error variance = $f(N_r).var_r + (1 – N/30).var$

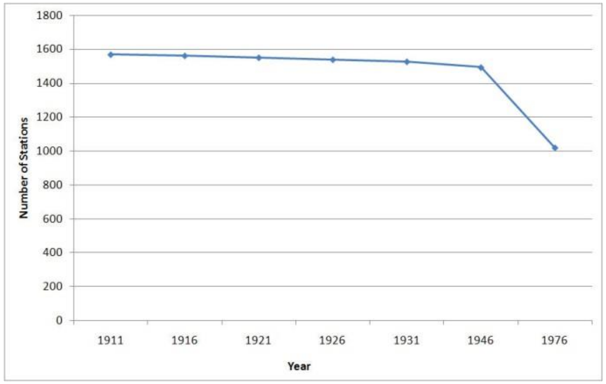
N_o at least 5 R at least 0.55

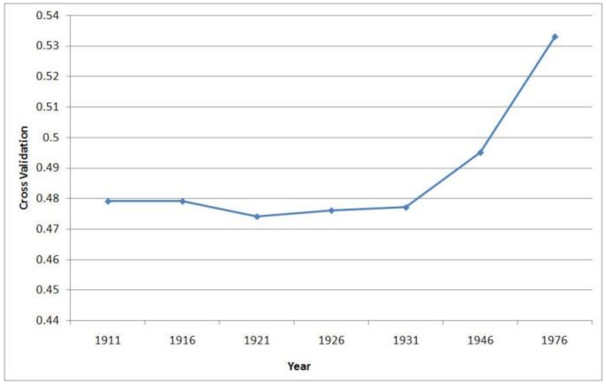
N at least 20 Error standard deviation less than 0.4°C

Standardisation of maximum temperature short period records to standard1976-2005 means

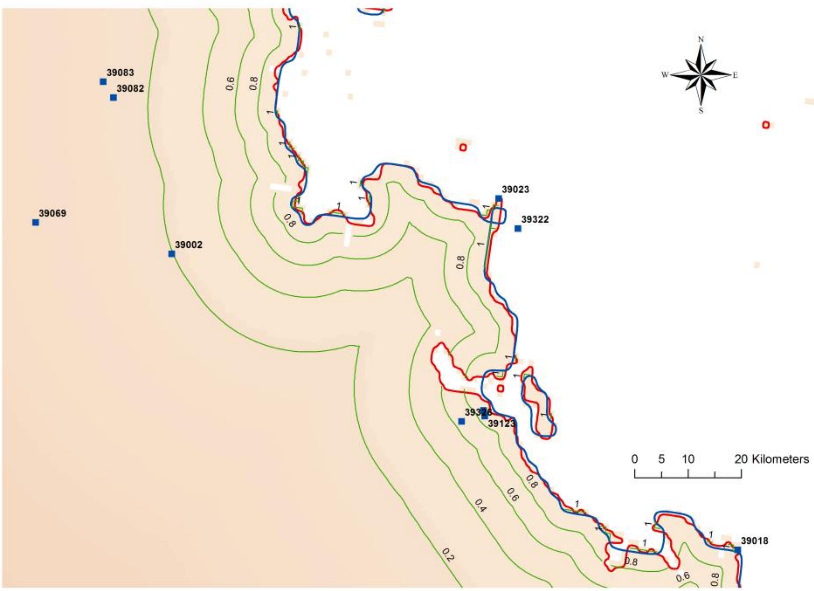




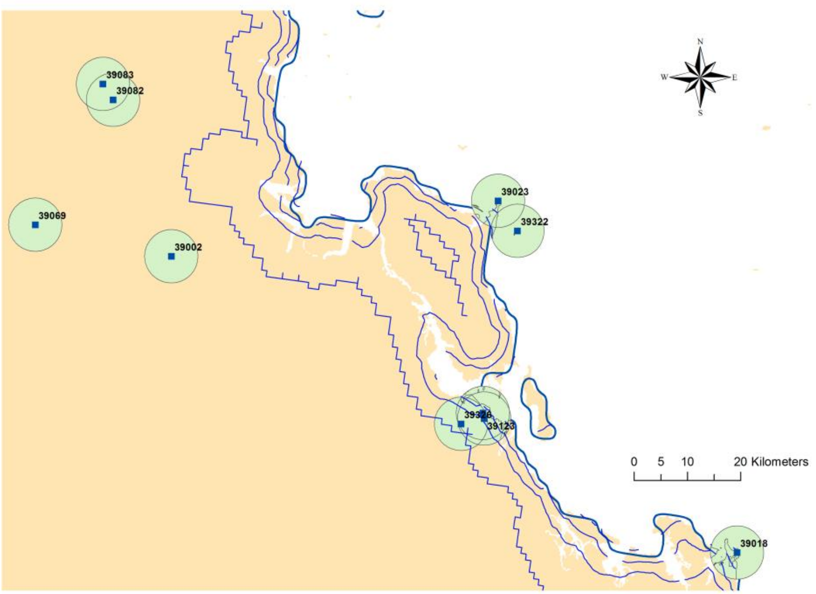




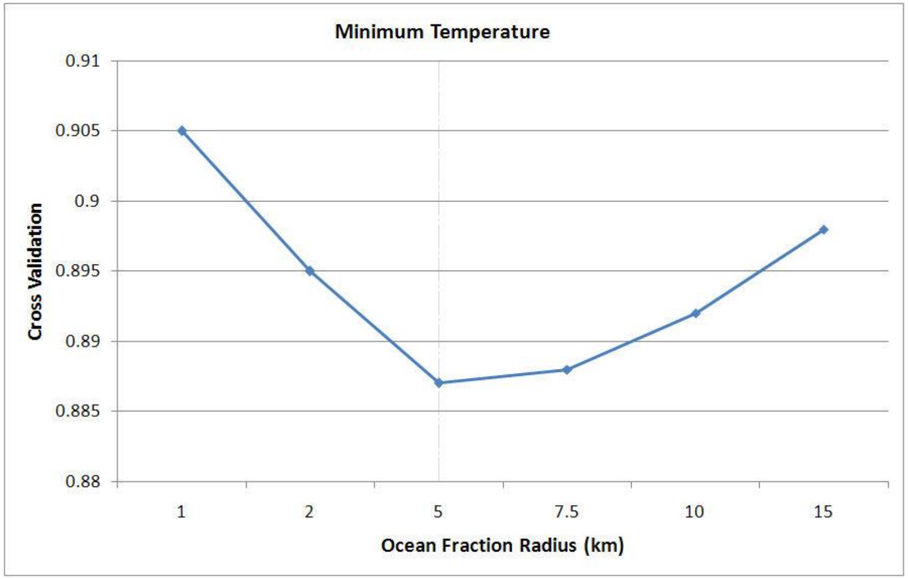
Distance based coastal proximity – max temp - wind

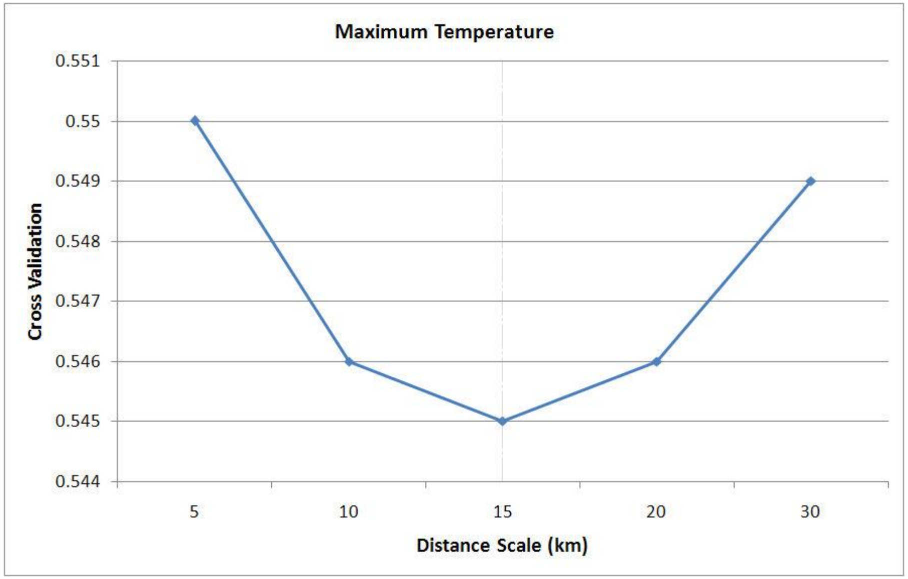


Proportion of area coastal proximity – min temp – local convection

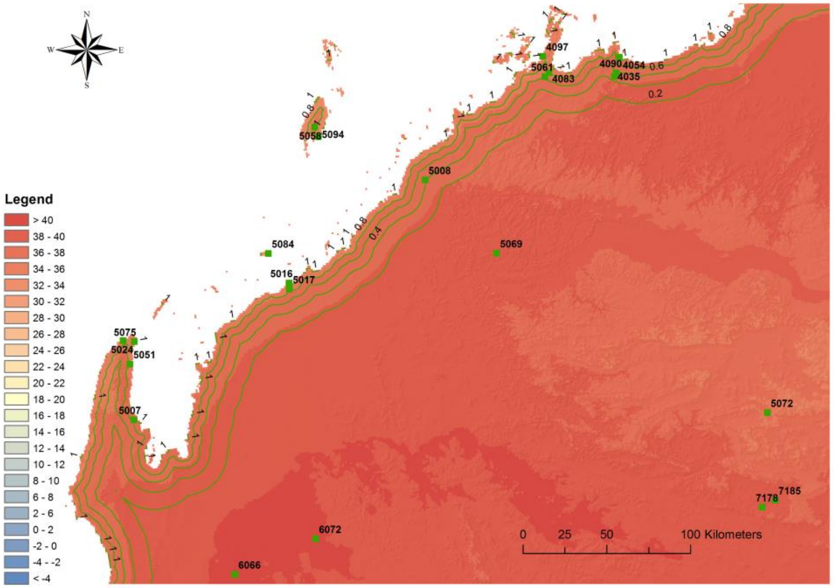


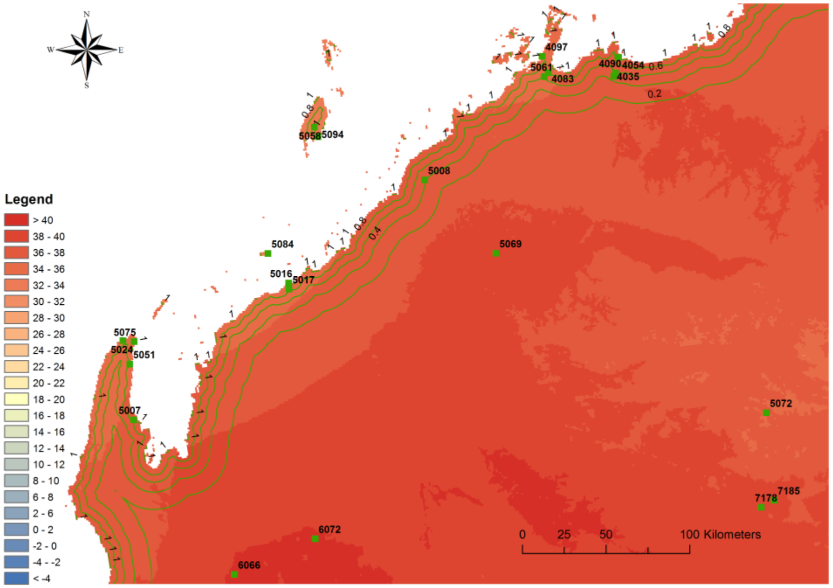
Optimisation of coastal proximity parameters



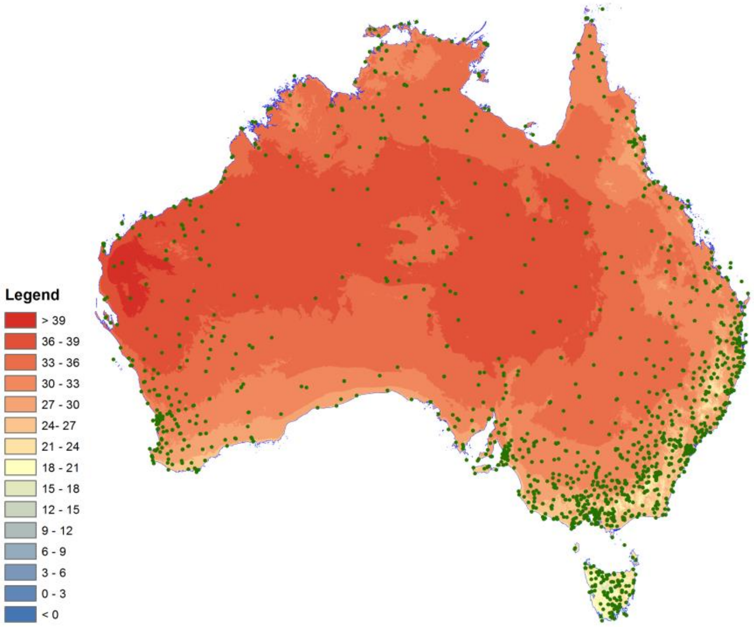


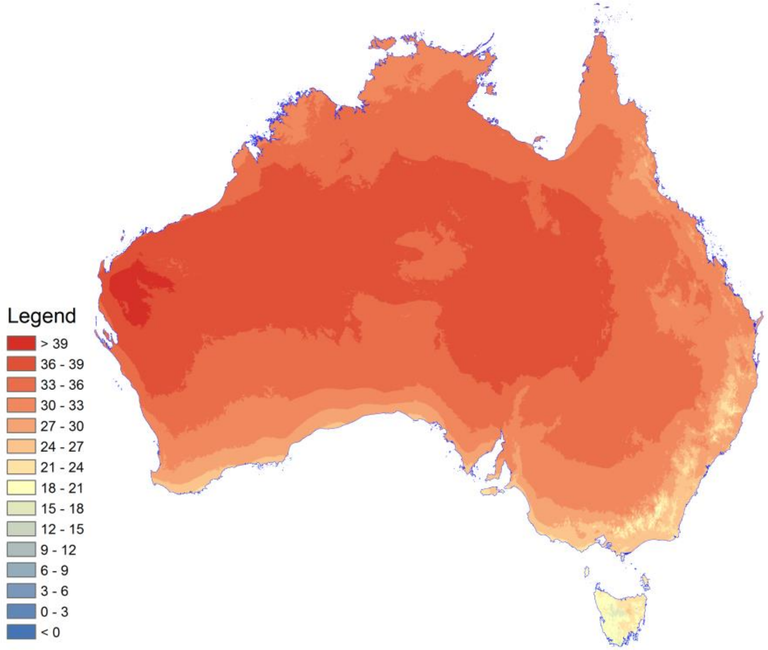
Impact of coastal proximity – sharper coastal transition with impact on broader scale patterns



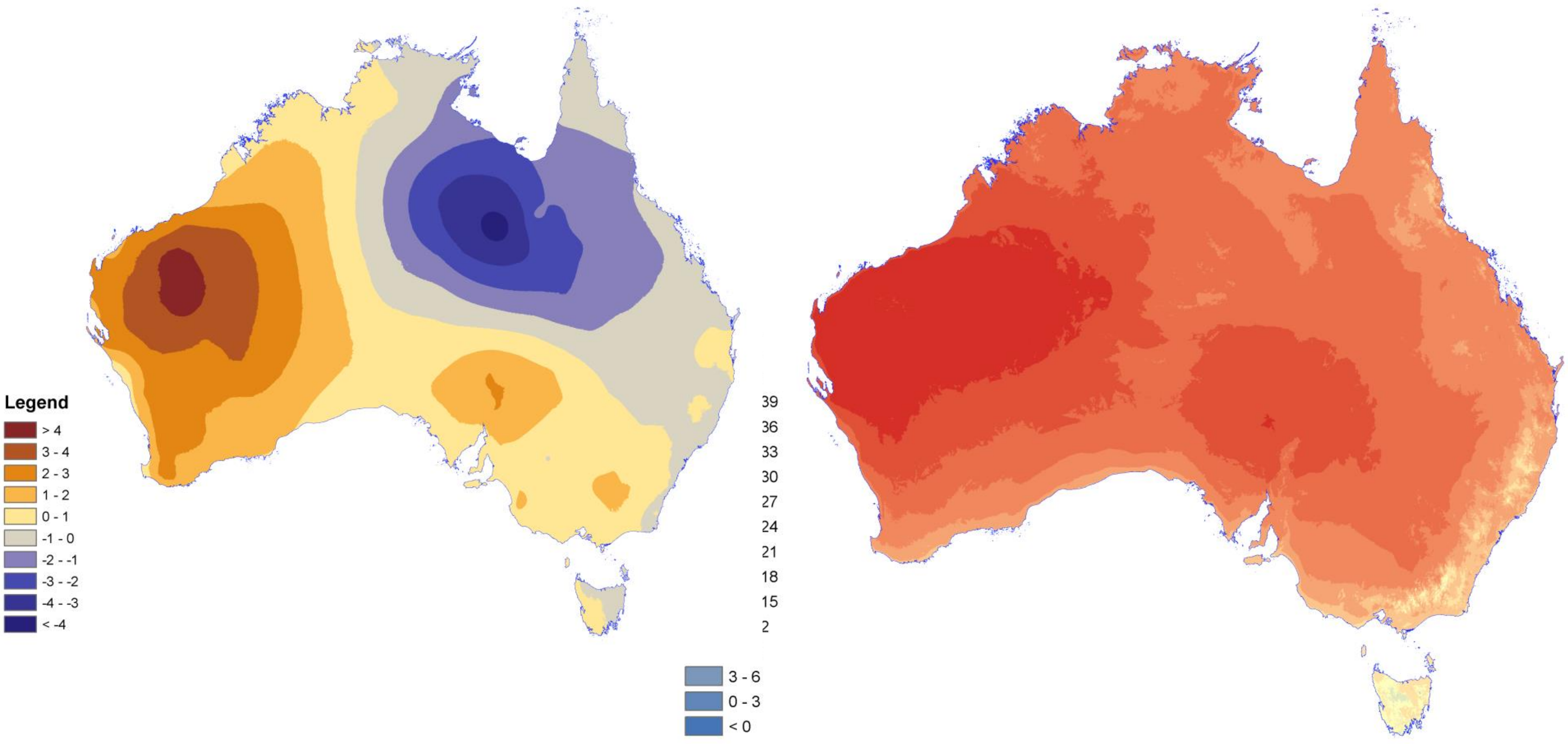


Impact of coastal proximity – February mean maximum temp – alters directions of spatial gradients in northern data sparse areas

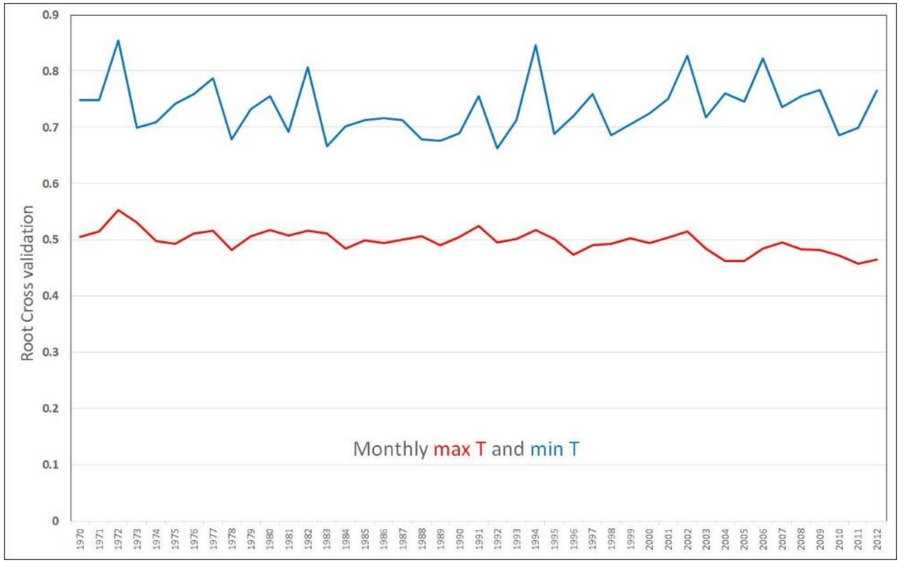


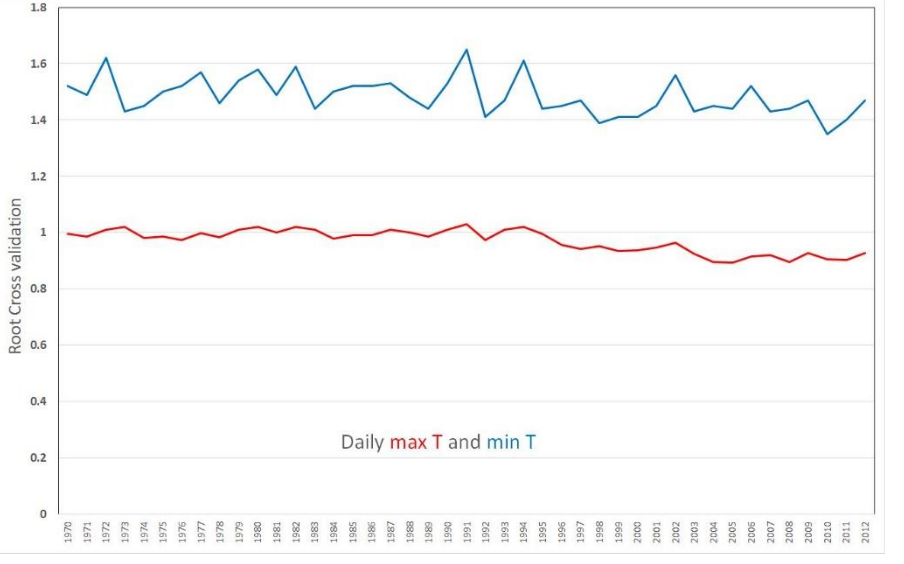


February 1977 anomaly and actual maximum temperature



Cross validation errors for monthly and daily Maxt and Mint over Australia 1970 - 2012





Mean monthly RMS CV errors

Maxt 0.50 °C

Mint 0.73 °C

Mean daily RMS CV errors

Maxt 1.0 °C

Mint 1.5 °C

Censored power of normal distribution

$Rain^{\alpha} = \mu + \sigma z$

α 0.3 – 0.9

z standard normal variable, $z \geq -\mu/\sigma$

μ/σ -3.0 to 2.0 $P(W) = \Phi(\mu/\sigma)$

Parameterisation of square root daily rainfall – basis for anomaly interpolation

Two parameters – calibrated monthly:

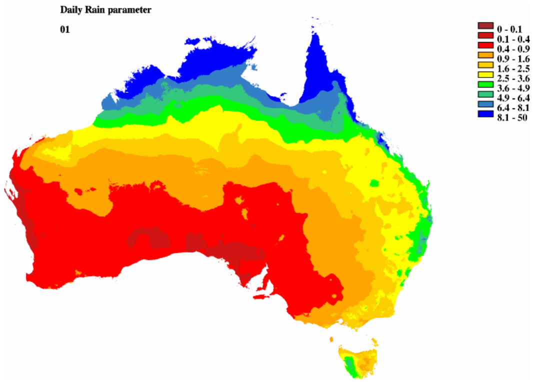
Mean daily rainfall = $f(\mu/\sigma).\sigma^2$

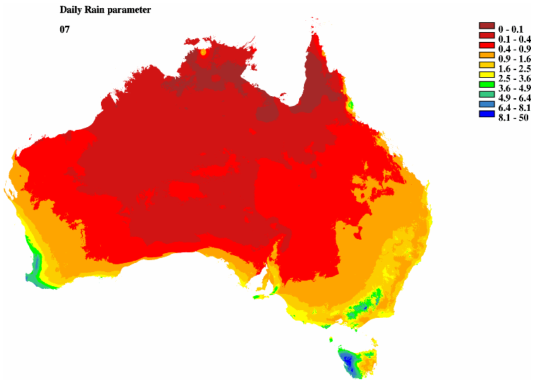
(σ ranges from 5 to 6)

$P(W) = \Phi(\mu/\sigma)$

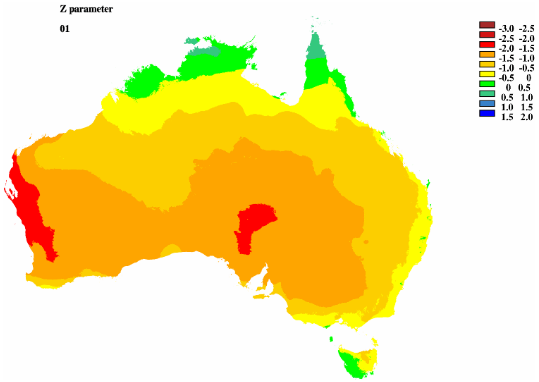
(μ/σ ranges from -3.0 to 2.0)

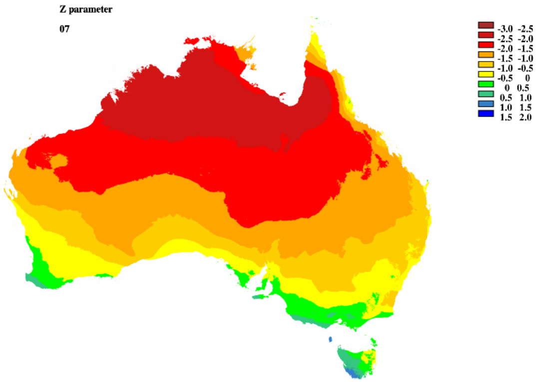
Mean daily rain mm/day 1976-2005 January, July





Φ^{-1}(Wet day probability) = μ/σ 1976-2005 January, July





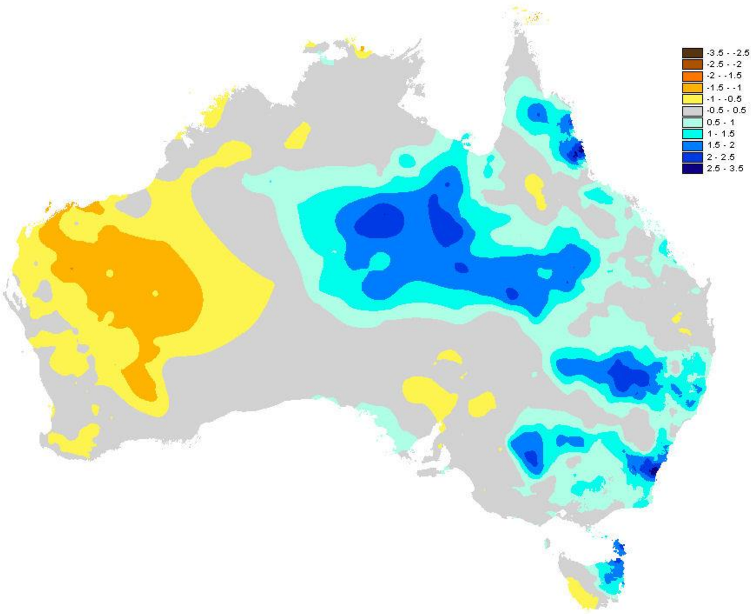
Defining the anomalies

- For positive rainfall – the z value of the underlying normal distribution - $z = (Rain^{\alpha} - \mu)/\sigma$

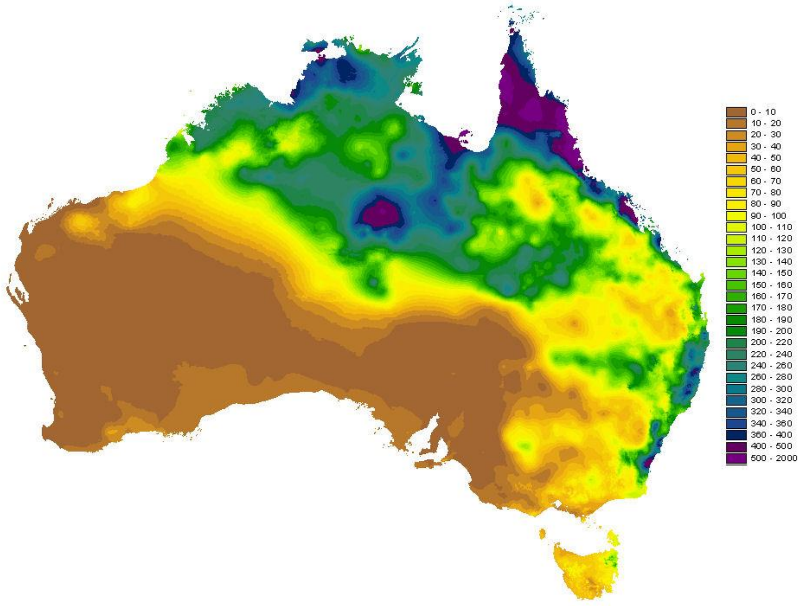
- For zero rainfall – invent a latent negative anomaly by placing the normalised value "mid-way" in the zero (dry day) probability region

February 1977 anomaly and actual monthly rainfall – strong east coast gradients due to topographic control of background field

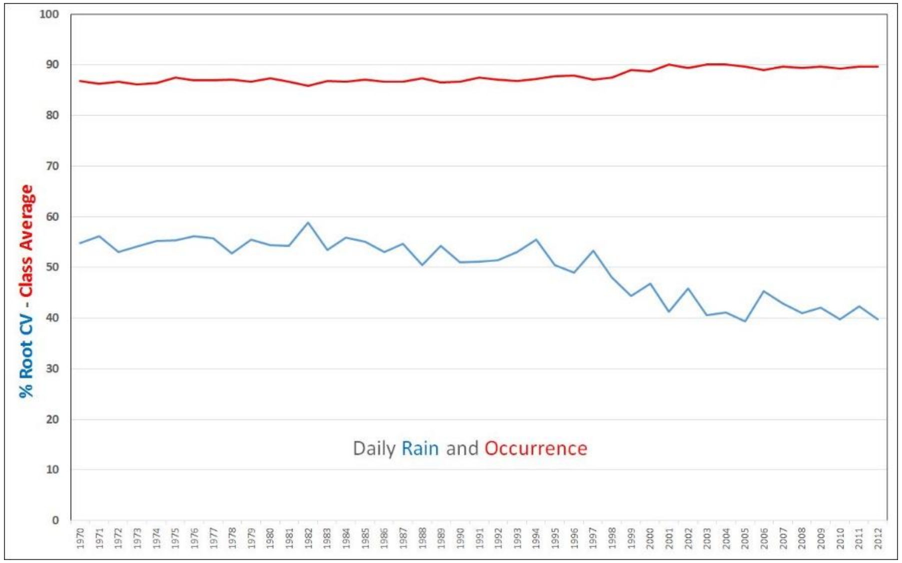
Monthly anomaly

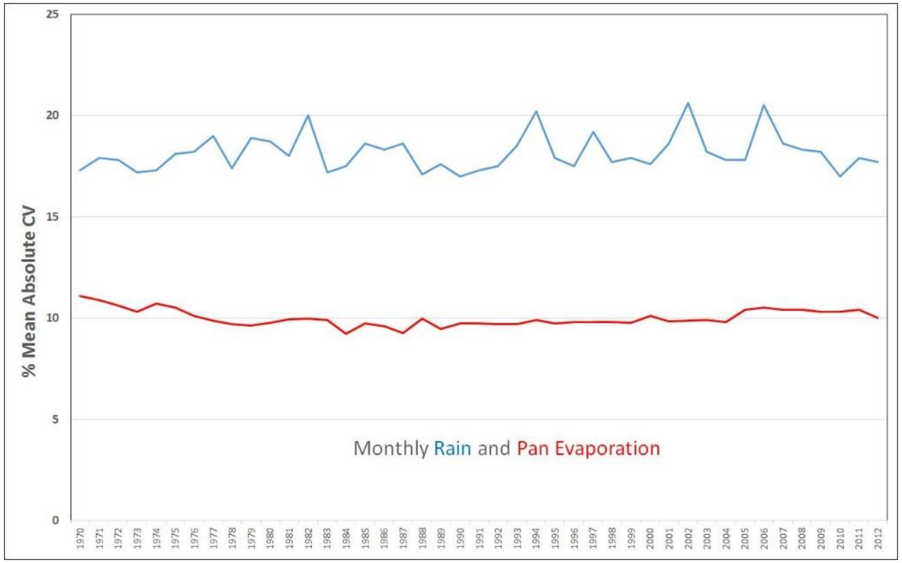


Actual monthly rainfall



Cross validation errors for rainfall and pan evaporation over Australia 1970 - 2012





Daily rainfall MA CV errors and daily occurrence class average

Rainfall 50%

Occurrence CA 90%

Monthly MA CV errors

Rainfall 18%

Pan Evap 10%

Robust rejection of erroneous daily rainfall anomalies

094129 1970 01 147.300 -43.033 73

0.00	75.90	5.80	2.00	5.30	1.00	0.00	0.00	0.00	0.00	11.70	6.90	0.00	0.00
0.00	1.09	63.47	6.67	4.75	4.17	1.51	0.00	0.00	0.00	0.00	11.07	11.78	0.95
0.02	0.31	70.34	7.11	4.67	4.50	1.51	0.00	0.00	0.00	0.00	11.33	12.43	1.02

094130 1970 01 147.551 -42.747 51

0.00	2.00	41.40	5.10	4.10	1.00	0.00	0.00	0.00	0.00	0.00	15.20	14.00	3.60
0.00	1.04	51.31	3.99	8.26	1.19	1.12	0.00	0.00	0.00	0.00	9.38	17.35	4.35
0.00	0.90	52.91	3.80	9.01	1.15	0.89	0.00	0.00	0.00	0.00	8.79	17.77	4.42

Daily rainfall station

Data values 1-14 January 1970

Fitted values

Cross validated values

Typical daily rainfall errors:

Wrong day of recording (as above)

Unrecognised accumulated values

Missing value recorded as zero

Error detection based on large studentised residuals - range of probability levels

Variable	Number of detections
Daily rainfall	5 per day
Daily max temperature	5 per day
Daily min temperature	5 per day
Monthly rainfall	16 per month (0.2%)
Monthly max temperature	2 per month
Monthly min temperature	2 per month
Monthly pan evap	0.5 per month

Conclusion

- Anomaly based interpolation provides a robust and accurate, process-based, spatial analysis of daily and monthly climate data
- New version of ANUSPLIN provides systematic implementation – addresses substantial housekeeping issues
- Studentised residuals provide an automated method for error detection - close inspection of data shows it to be reliable – potential for further application
- New anomaly process for daily and monthly rainfall offers potential for incorporation of additional remotely sensed predictors
- Cross validation errors provide an assessment of ground network quality – confirmed improvement in quality of Bureau of Meteorology ground data since the late 1990s
- Potential for wide application in ecosystem assessment and modelling and impact assessment