

# PARSIMONIOUS SIMULATION OF DAILY RAINFALL FIELDS



B BENNETT, M THYER, M LEONARD , M LAMBERT AND B BATES

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# Introduction

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- Design and management of water systems relies on inputs of rainfall and/or streamflow
  - ▣ Evaluate Drought Risk
  - ▣ Evaluate Flood Risk
  - ▣ Evaluate Ecological Risk
- Historical data provide results that are only one realisation of the past climate
  - ▣ Produces unreliable estimates of risk
- Stochastic data → improve estimates of risk

# Stochastic Data

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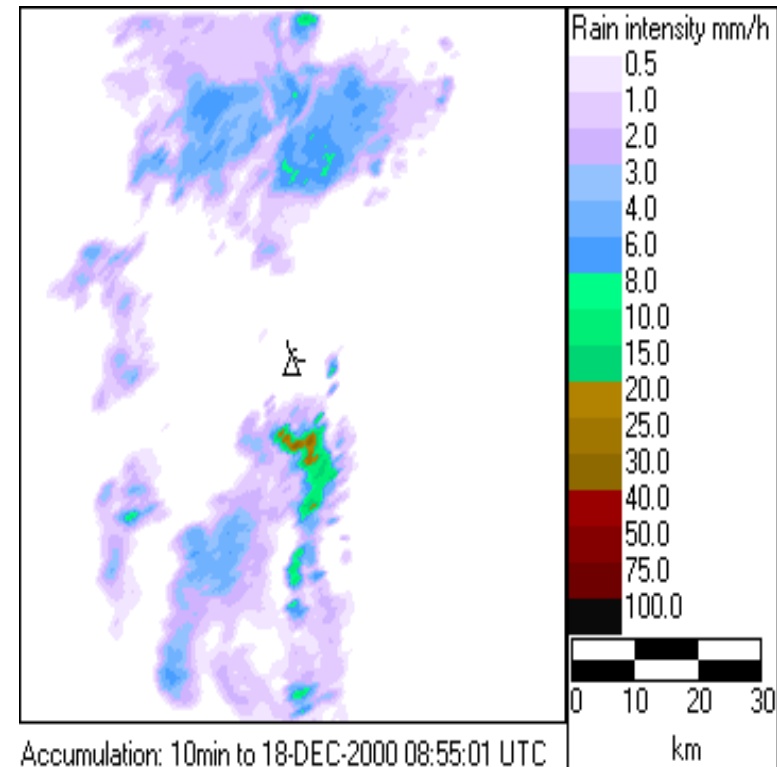
- Stochastic hydrological data
  - ▣ Random numbers (stochastic time series models)
  - ▣ Calibrated to have same statistical characteristics as historical data
- Provides multiple time series of data
  - ▣ Each time series is an alternative realisation that is equally likely to occur
  - ▣ Use as input into models to quantify uncertainty
    - Hydrological models
    - Ecological models
    - Storage yield analysis
    - Water resources models



# Stochastic Data

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- But - Risks correlated in space
  - ▣ Drought, flood, ecological response
- Need spatial stochastic data

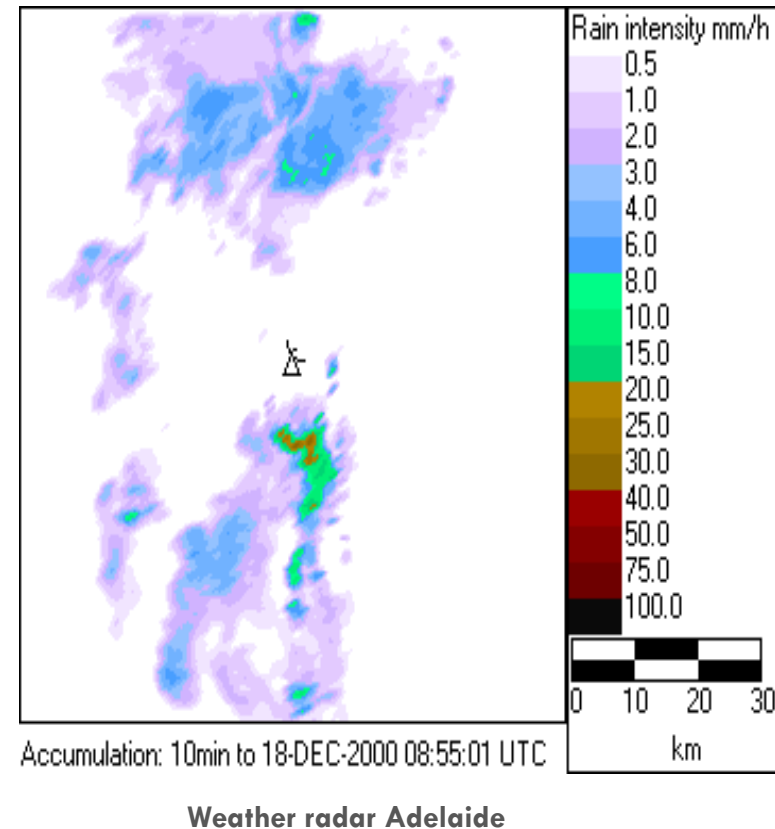


Weather radar Adelaide

# Need Spatial Stochastic Rainfall Data

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- Spatial variability of rainfall significantly affects catchment response
- Better understanding & prediction of flood & drought risk



# No easy, flexible rain field simulator

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- Current approaches poorly capture spatial variability
  - Interpolation of observations -No time consideration, conditional, no stochastic estimate of risk
  - Multisite - limited ability to capture space-time variability
  - Spatial models - Too complex, challenging to calibrate, un-realistic spatial patterns i.e Spatial Neyman-Scott models

# A continuous daily rain field model

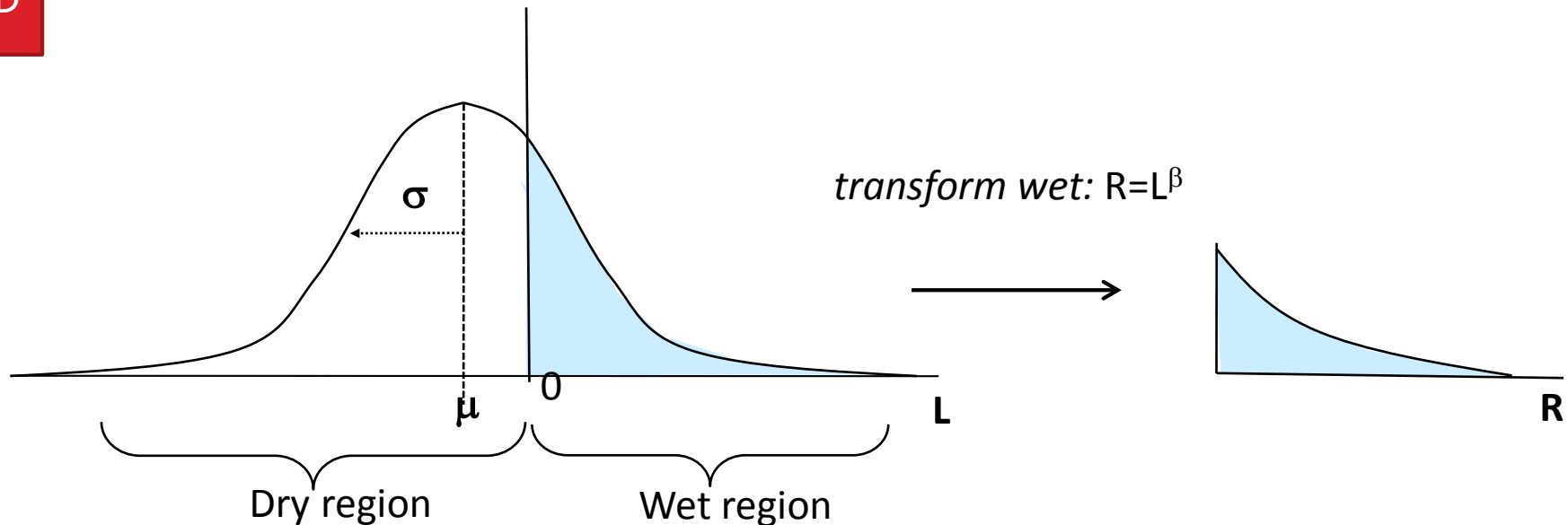
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- Simulation of the full field evolving in time
  - ▣ Parsimonious and flexible approach
    - Latent variable approach – conditions amounts on occurrences and incorporates skewness
- Continuous simulation of unconditional rainfall fields
  - ▣ Flexible, Parsimonious
  - ▣ On grid
  - ▣ Choose your own spatial resolution
  - ▣ Stochastic realisations - better risk estimates

# Simulation of spatial field with truncation

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1D

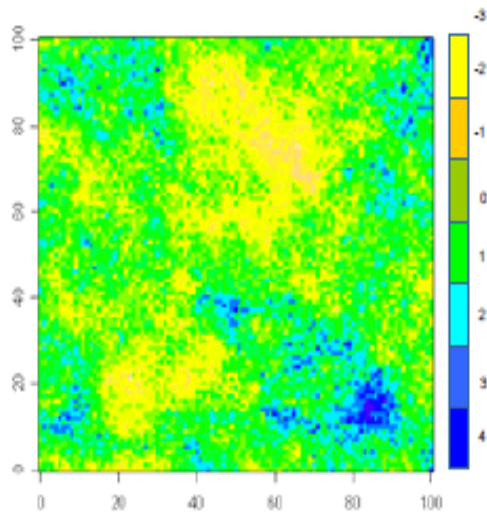


- $\mu$ ,  $\sigma$ ,  $\beta$  at each site – interpolated over region – parameter surface
- Temporal Correlation – lag-1 autoregressive model (constant  $\phi$  for region)

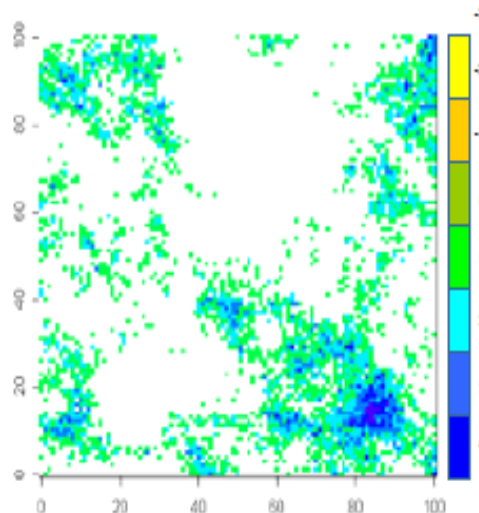


# Simulation of spatial field with truncation

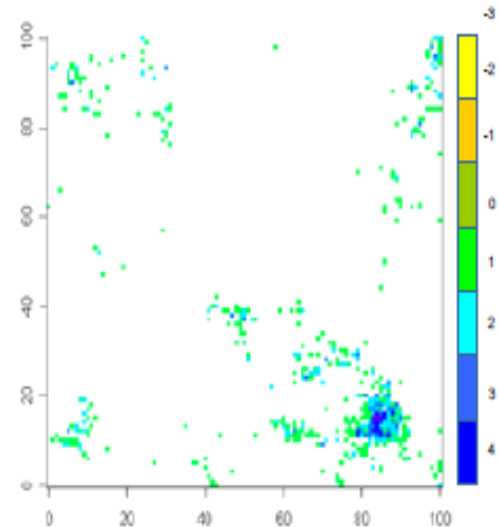
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(a) Latent variable ( $L$ )



(b) truncated variable ( $L > 0$ )



(c) transformed rainfall ( $R$ )

- Spatial correlation function— powered exponential (isotropic)
- 12 seasons — parameters vary seasonally

# Onkaparinga Study

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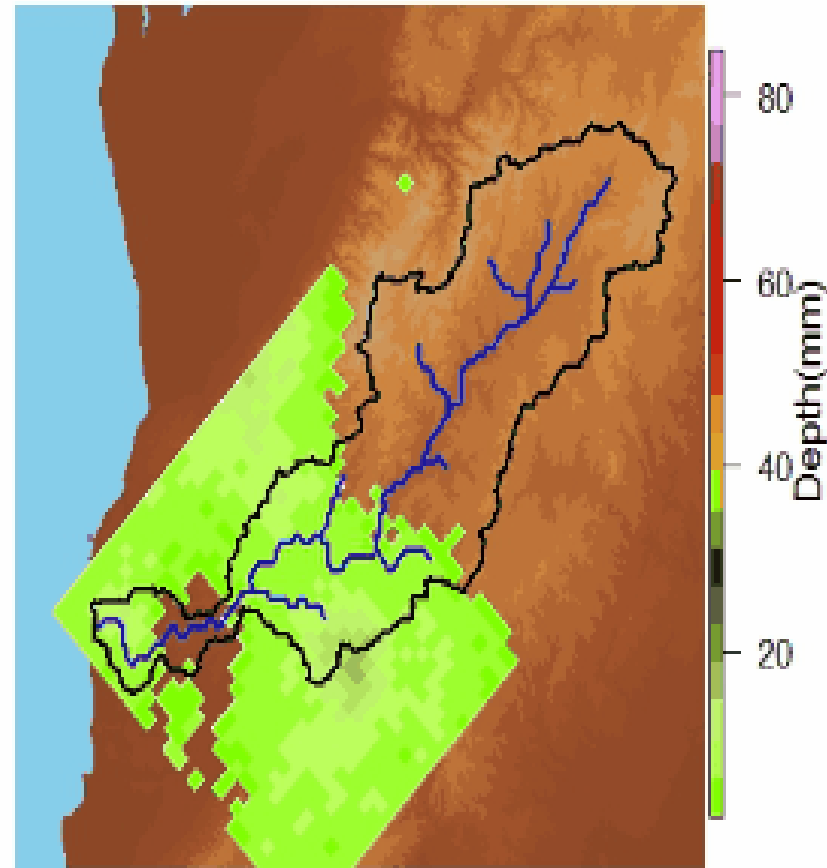
- Adelaide's major water supply catchment
- Data
  - ▣ 73 yrs high-quality observed rainfall
  - ▣ 19 sites inside grid



# Realistic continuous rainfall fields




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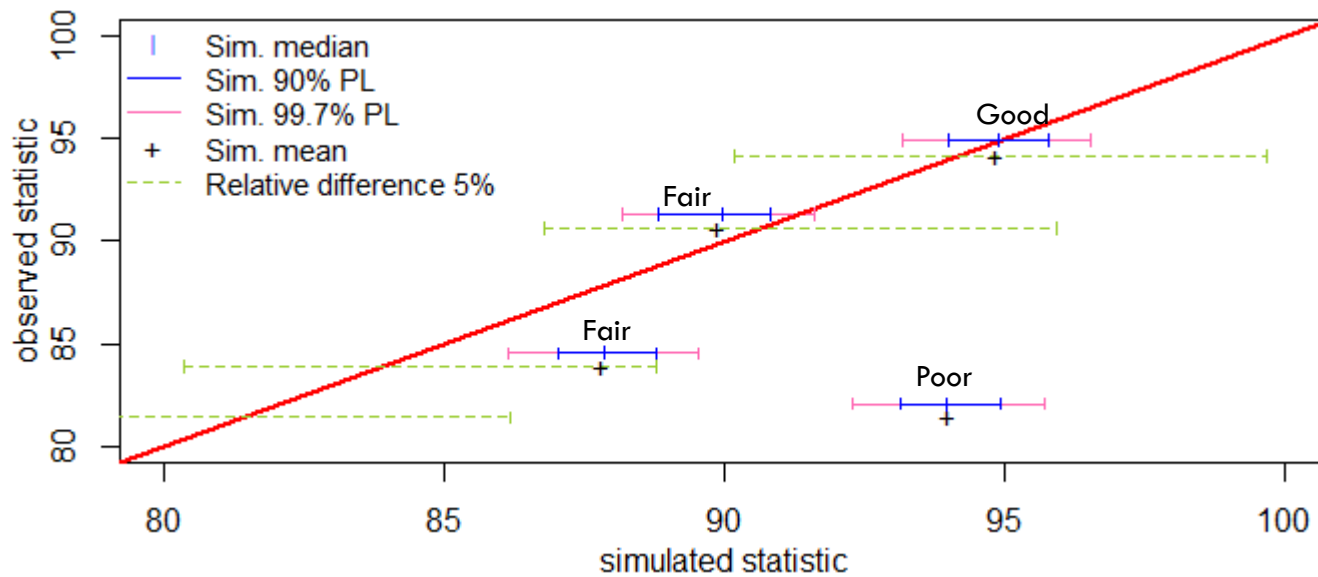
- Simulation
  - ▣ 100 replicates
  - ▣ Grid -  $0.78\text{km}^2$
- Capturing the spatio-temporal statistics of rain fields



# Performance classification scheme

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Performance Classification	Key	Test
Good		Less than 10% of observations outside 90% limits
Fair		More than 10% of observations are outside 90% limits but within the 99.7% limits OR within 5% of observed mean
Poor		Otherwise



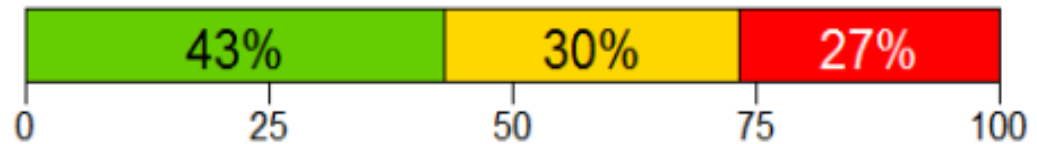
# Performance classification scheme

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Good

Fair

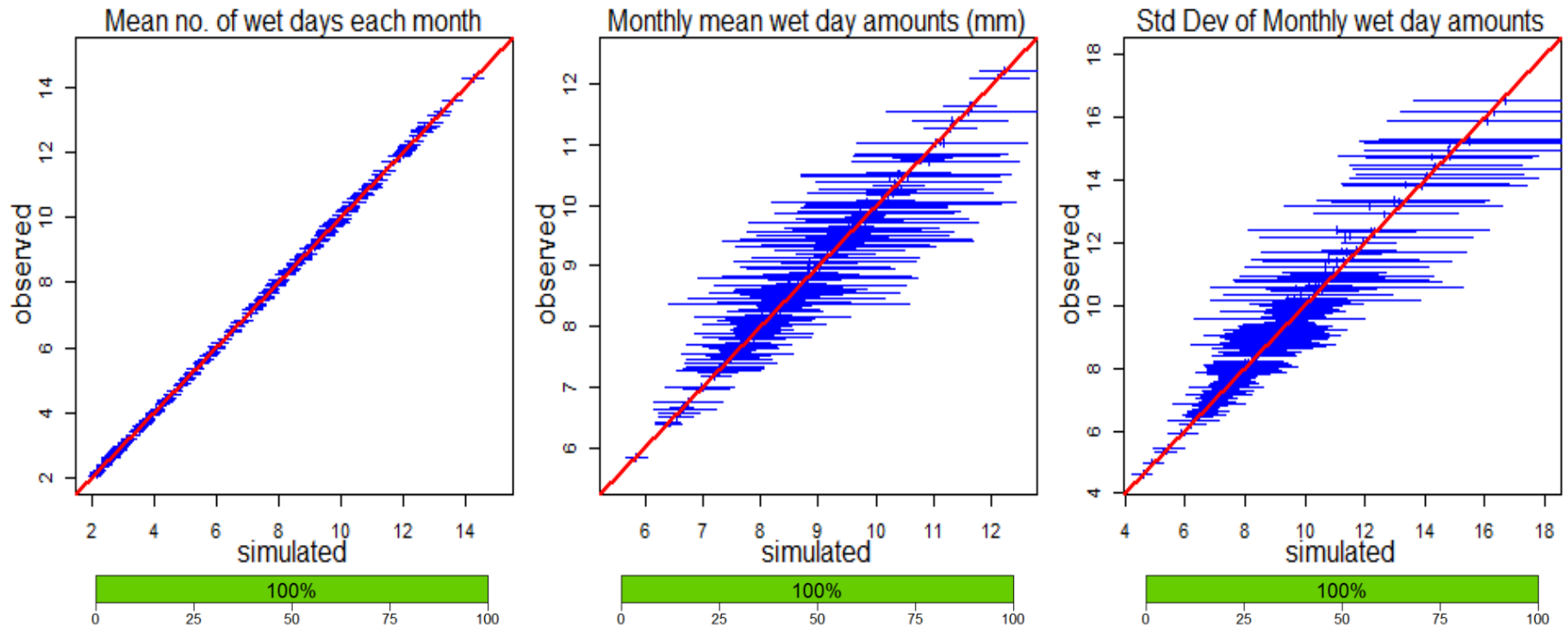
Poor



- Bar plots present performance as a percentage of sites

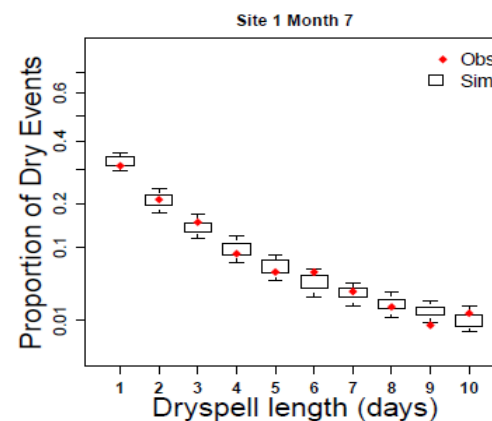
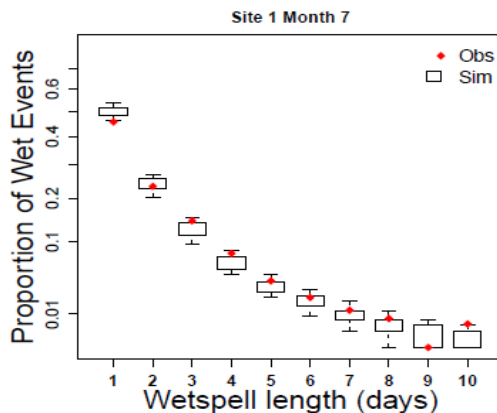
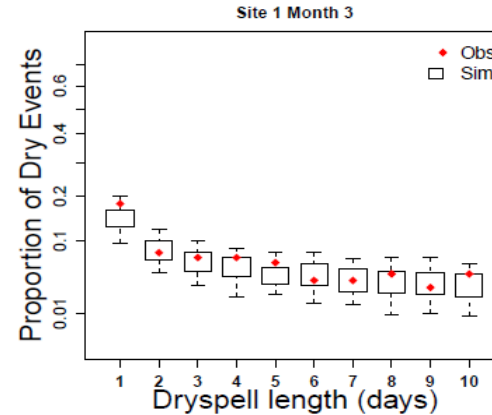
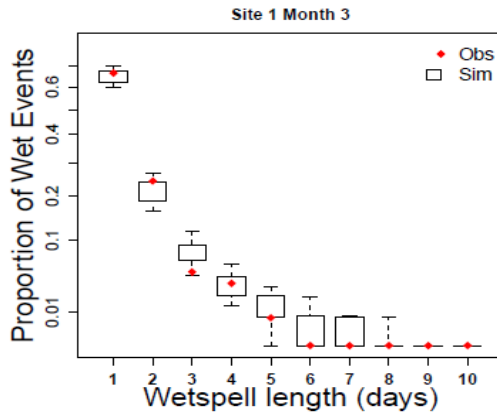
# Verified model structure at daily level - marginal

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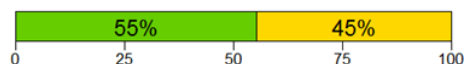


# Verified model structure at daily level - temporal

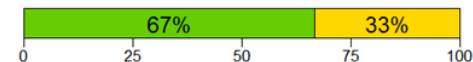
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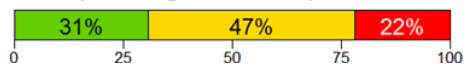
Wet spell length MAMJJA performance



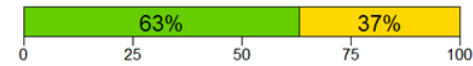
Dry spell length MAMJJA performance



Wet spell length SONDJF performance

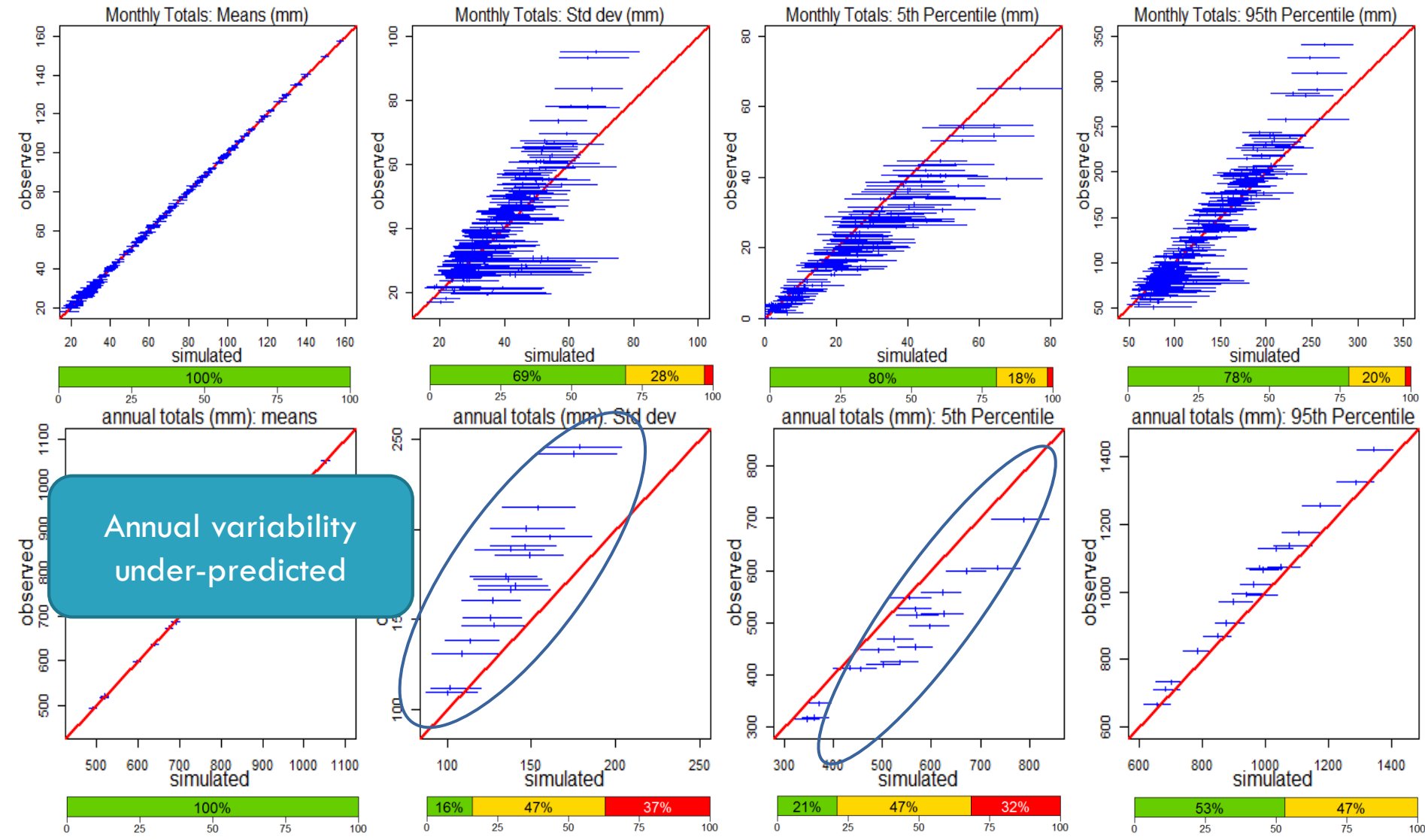


Dry spell length SONDJF performance



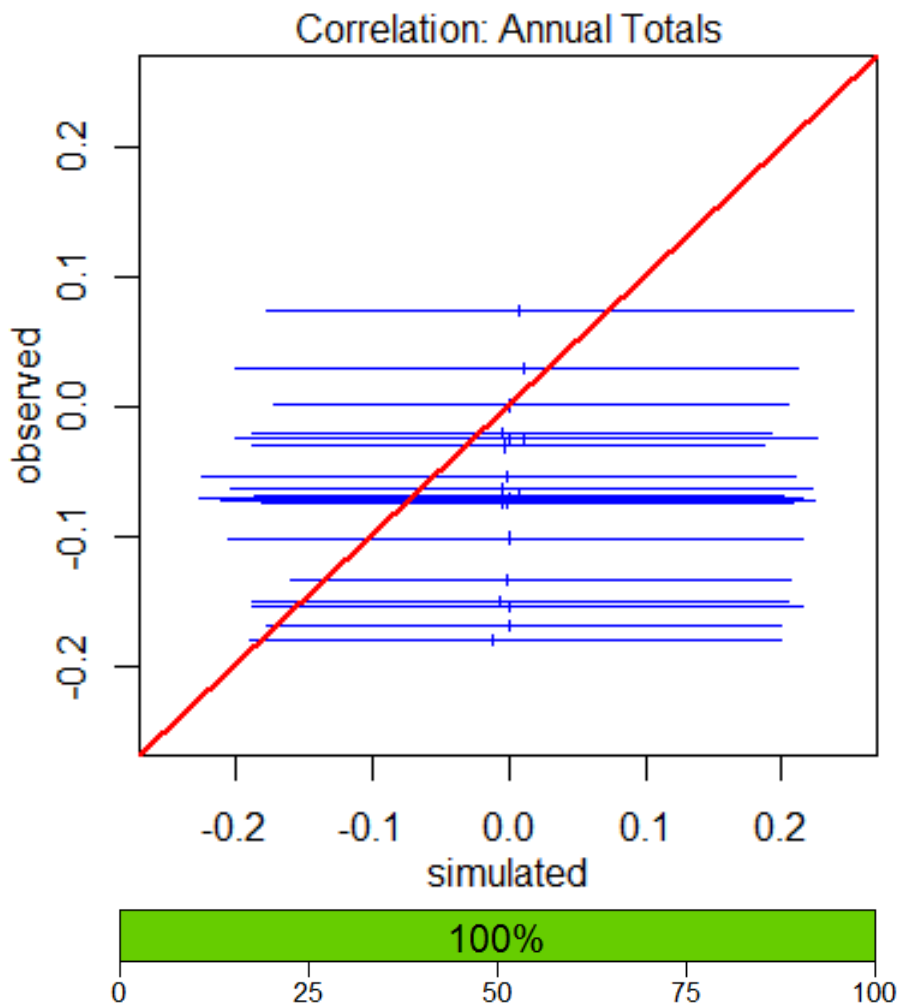
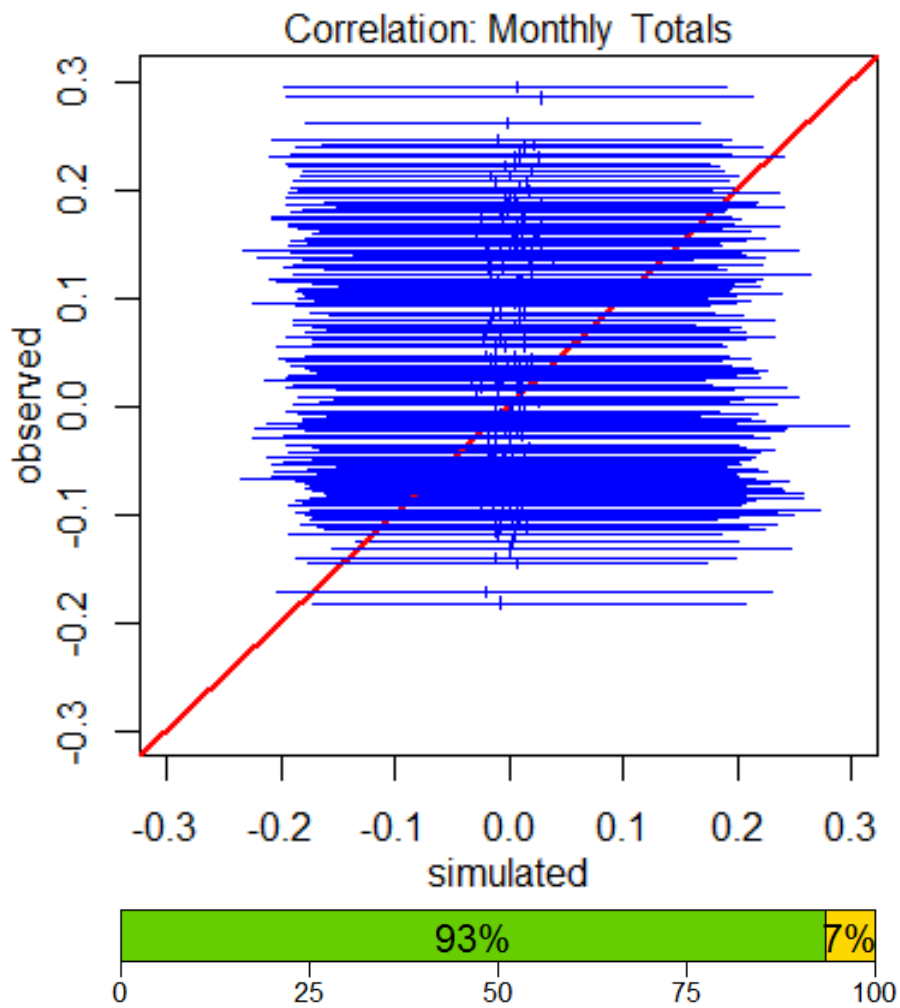
# Aggregate totals test – majority good

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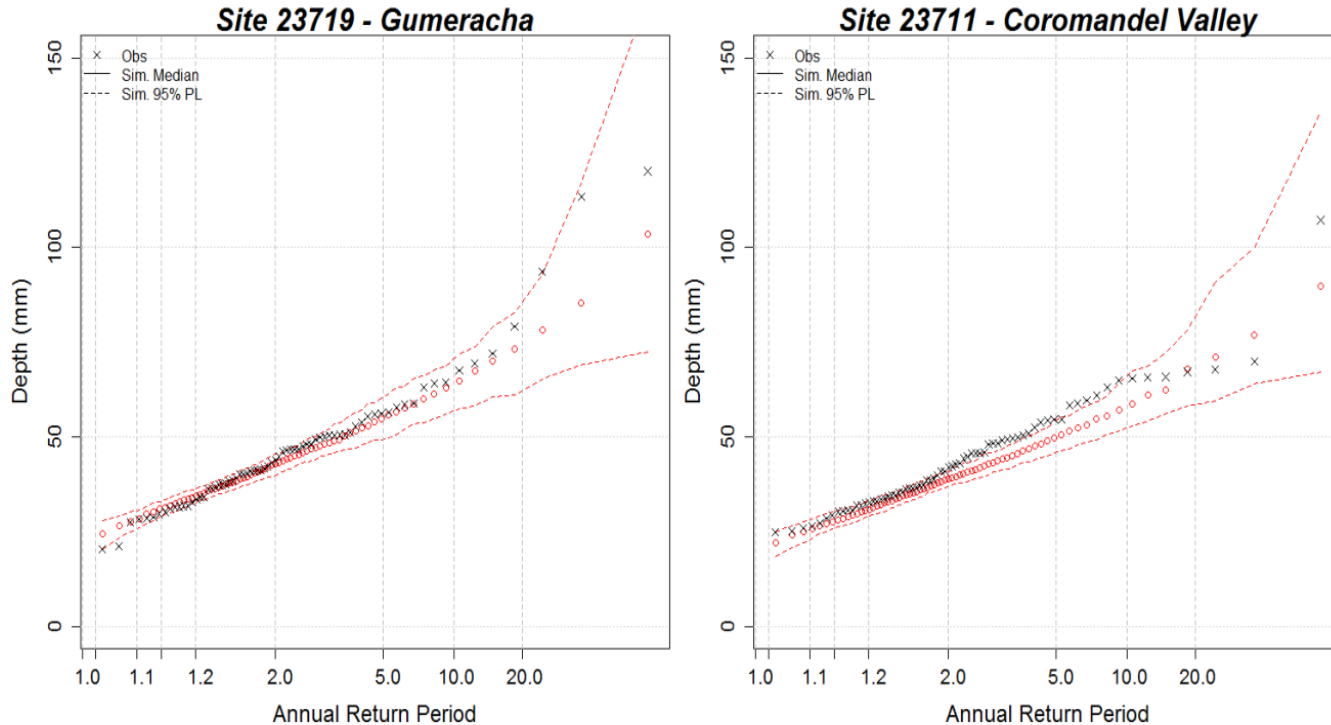
# Month-to-month and yearly correlations preserved



# Rainfall extremes: Overall good

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Cumulative performance over all sites



□ Emergent property – not calibrated

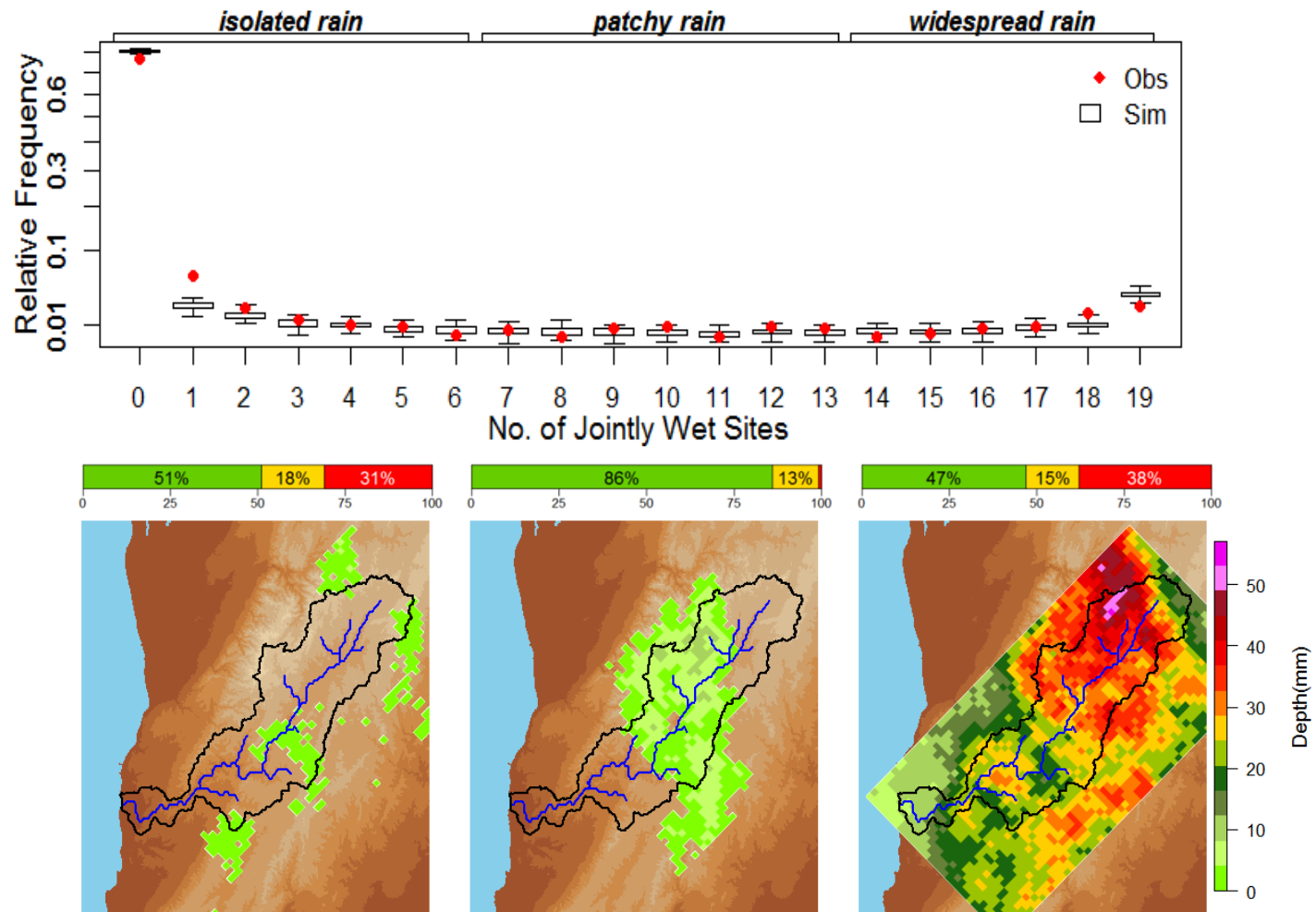
# Cross-validation Shows Good Performance

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# Space-time occurrence well preserved

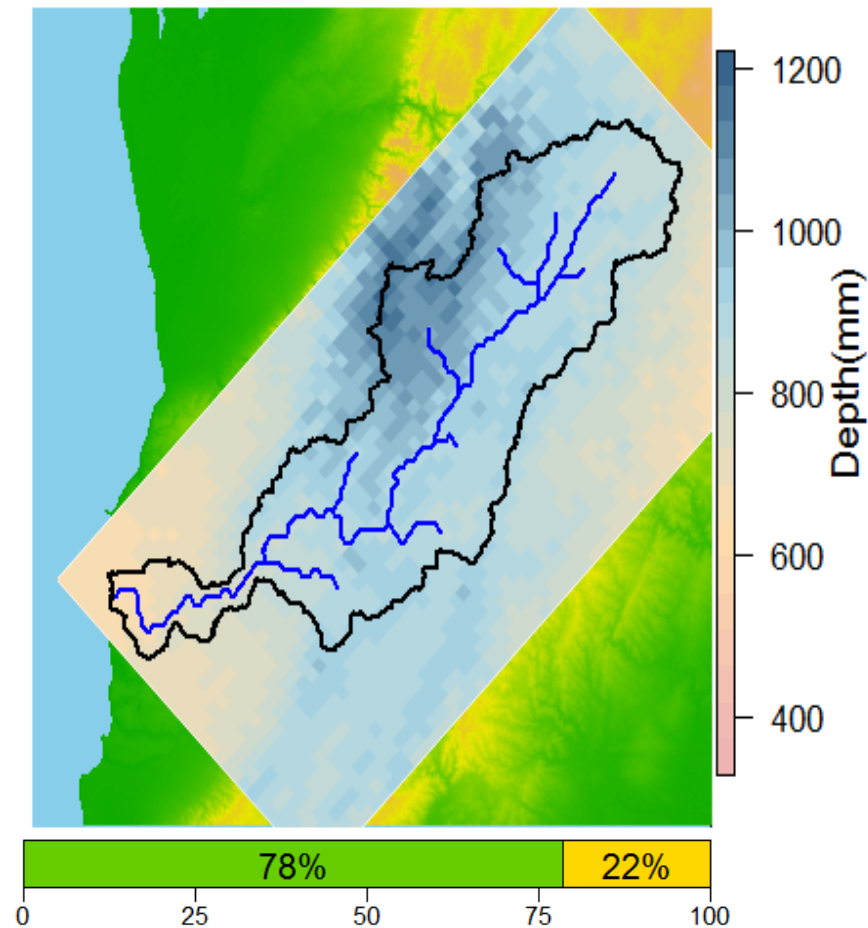
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# Spatial Rainfall Gradient Preserved

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## Average Annual Total Rainfall

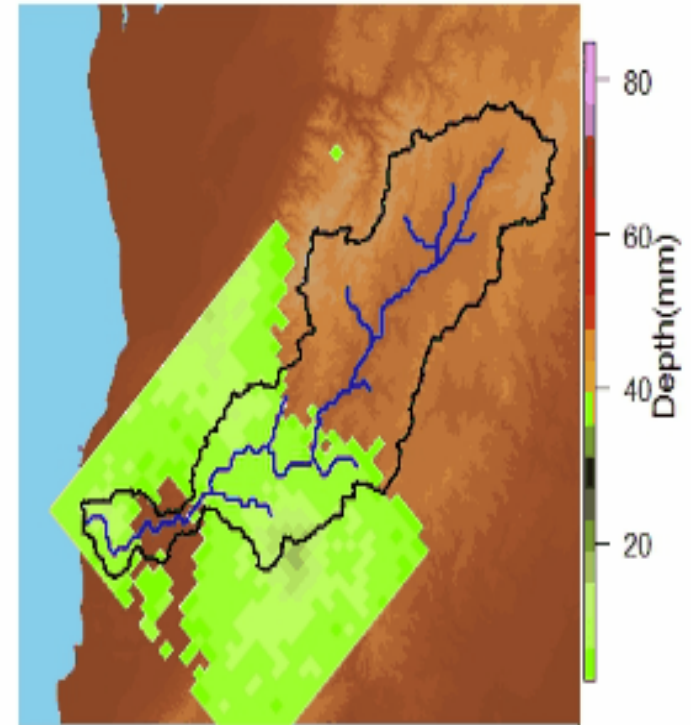


Cumulative performance over all grid locations

# Advantages

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- Parsimonious & flexible
- Stochastic realisations
  - Better stochastic estimates of risk
- Continuous spatial fields
- Choose your own resolution



# Next steps

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- Improve inter-annual variability
  - ▣ Assumption of stationarity
- Radar data to inform spatial correlation structure
- Locations with tropical weather systems
- Conditioned on observations, GCMs, Weather types