School of Civil, Environmental and Mining Engineering

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A new approach for annual flood frequency estimation: Hybrid Causative Event Method

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Overview

- Motivation
  - Why a new approach for flood estimation?
- Innovations and Methodology
  - What is the hybrid causative event based approach?
  - How do we incorporate seasonality?
- Case studies
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Why do we need a new approach for flood estimation?

1. Flood frequency analysis
   - Requires long stream flow data
   - **Issue:** Unreliable for predictions of climate and land-use changes
2. Derived Flood Frequency Methods
   - Based on model simulations
   - Rainfall Model => Hydrological Model => Flood Frequency Distribution
   - Potential to provide predictions for climate change and land-use changes

Derived flood frequency methods

Rainfall Model => Hydrological Model => Flood Frequency

1. Event-based approaches
   - Joint probability approach (JP) (e.g. RORB)
   - Efficient => focus on extreme events of interest
   - Requires distribution of extreme rainfall and catchment wetness (losses)
   - **Issues**: - Losses estimated based on observed events
     - How will identify losses under climate change?
2. Continuous simulation => Saviour?
   - No need for rainfall/loss distribution or AEP neutrality
   - **Issues**: Computational intensive
     - e.g. ~ 20% accuracy in 1% AEP flood requires 10,000 years simulation!!
     - Not feasible for anything but simplest models

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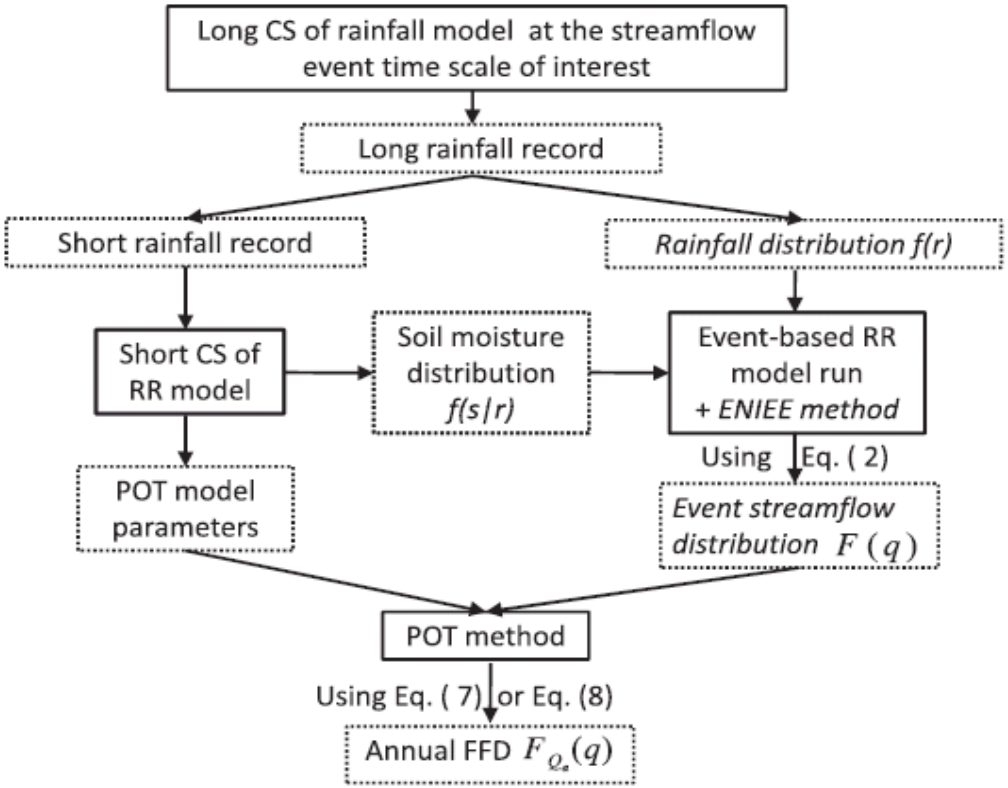
Hybrid Causative Event (HCE) Method

- Combines **accuracy** of continuous simulation (CS) with **efficiency** of event based joint probability (ES-JB) approach
- Incorporates joint probability of flood generation processes but without AEP neutrality assumptions
- Uses causative events of streamflow to estimate annual FFD



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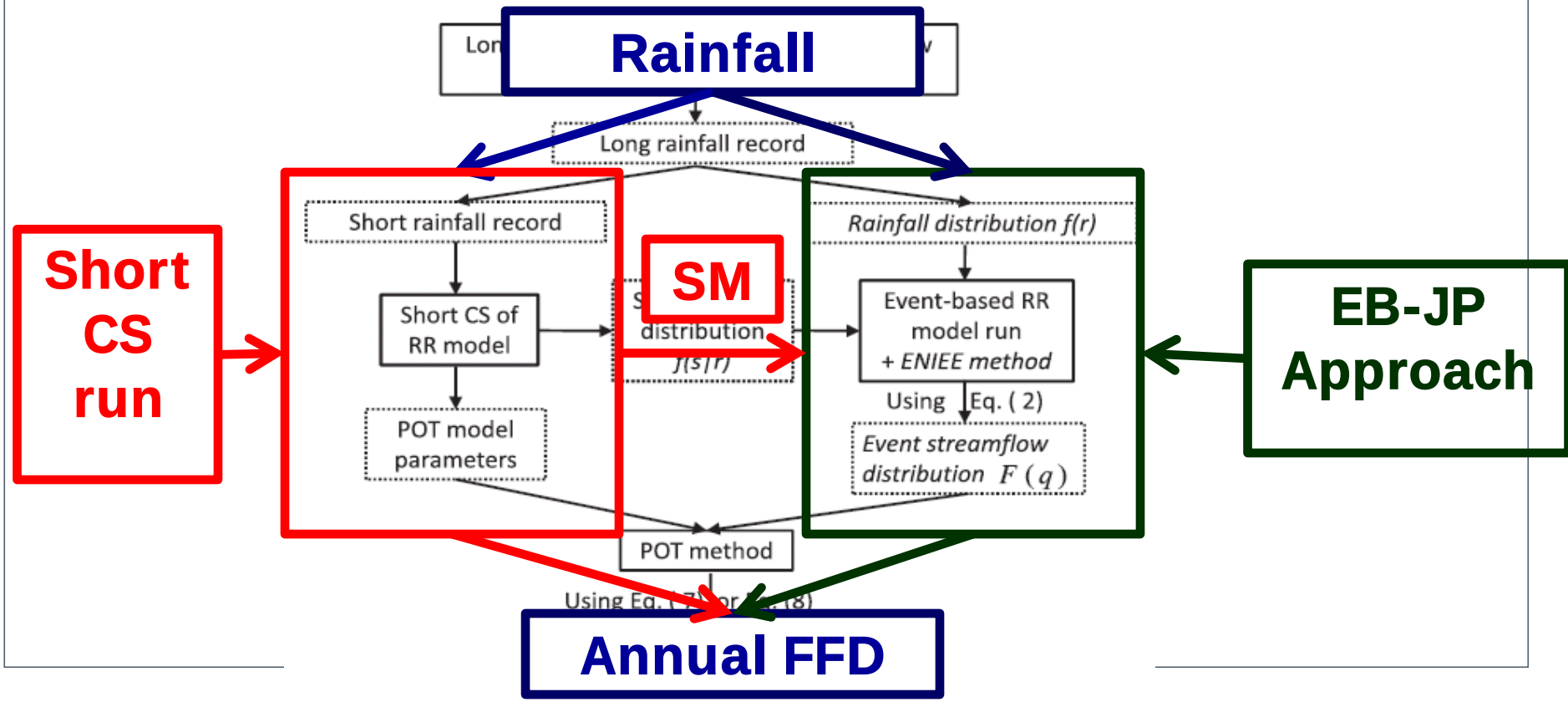
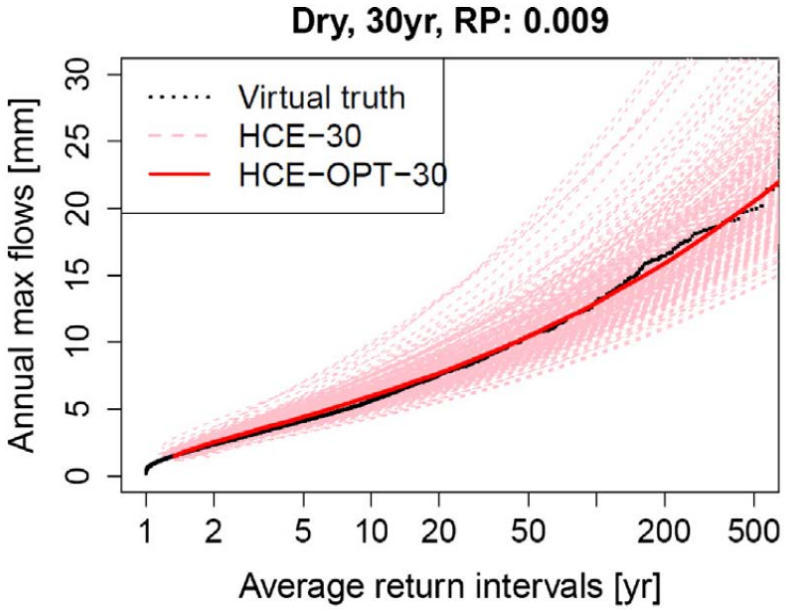
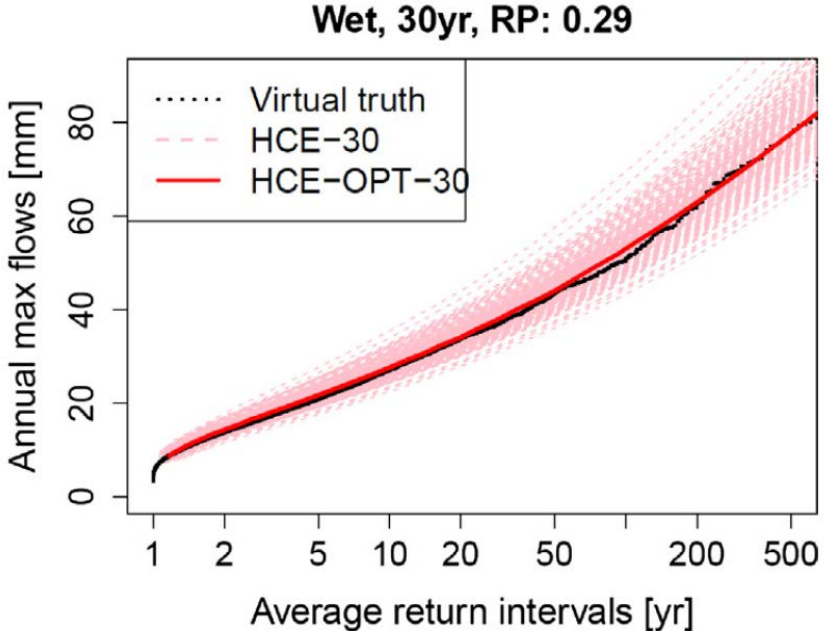


Hybrid Causative Event (HCE) Method

- Evaluated "Virtual Laboratory" Approach (Li et al, 2014)
  - Stochastic rainfall (no seasonality) and simple rainfall-runoff model
- **Robust:** Using only 30 years of data HCE accurately reproduce flood frequency distribution from 10,000 year CS
- **Efficient:** HCE is 100-1000 times faster then continuous simulation

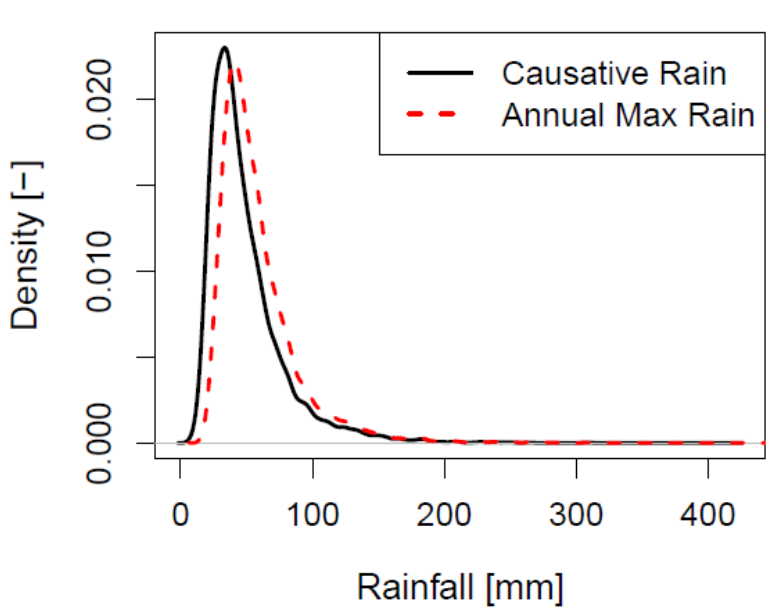


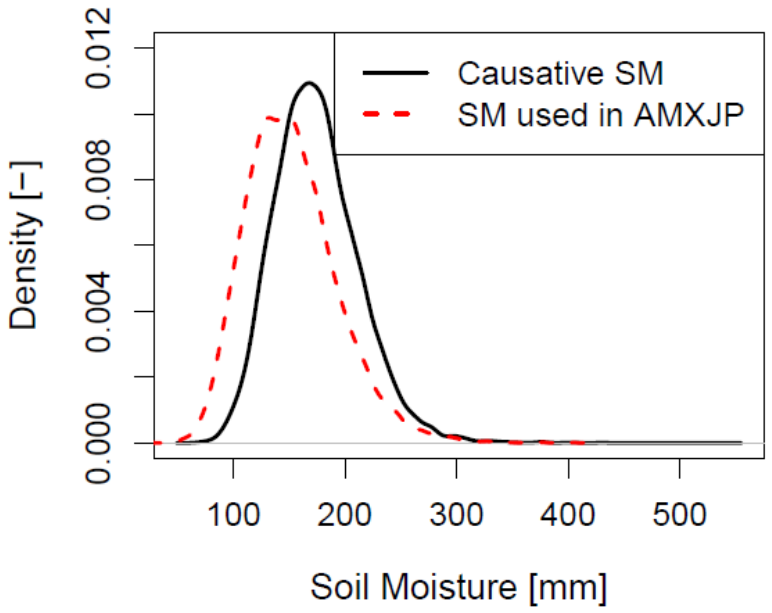


Li, J., M. Thyer, M. Lambert, G. Kuczera, and A. Metcalfe (2014), An efficient causative event-based approach for deriving the annual flood frequency distribution, *J Hydrol* http://dx.doi.org/10.1016/j.jhydrol.2013.12.035

Existing Event-Based Joint Probability Methods

- Evaluated "Virtual Laboratory" Approach (Li et al, 2014)
- Uses annual maximum rainfall and soil moisture conditioned on a rainfall POT series => not causative events





- Accurate reproduction of flood frequency distributions relies on compensation of errors => rather then causative events

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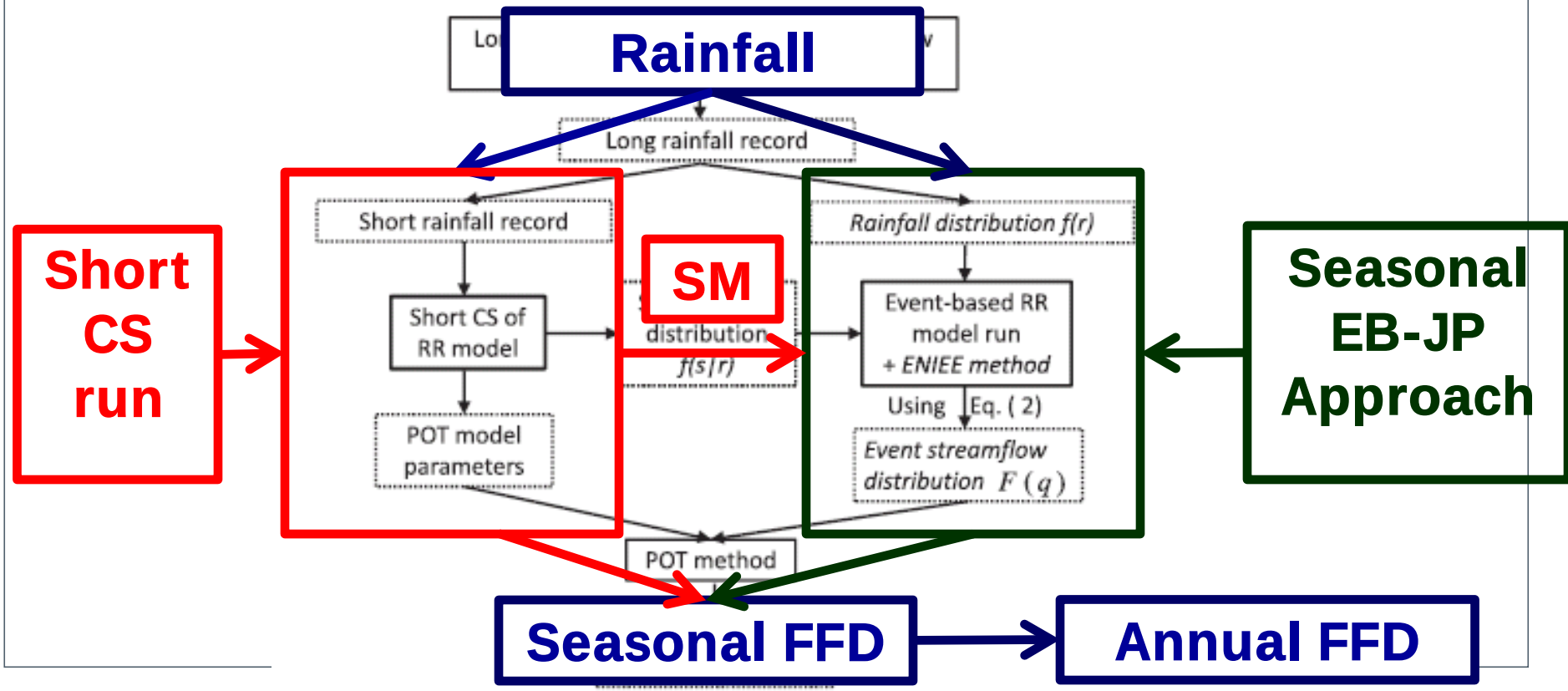
Hybrid Causative Event (HCE) Method

- Incorporating Seasonality
- Use short CS Run
- Inform event-based JP approach for different seasons
- Combined seasonal FFD into annual FFD



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- Motivation
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  - Evaluating seasonal HCE on wide range of climatology's
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Seasonal HCE Evaluation: Case Studies

- Evaluated using Virtual Laboratory Approach (Li et al, 2016)
- **Realistic Rainfall**:DRIP Stochastic sub-daily rainfall (storm durations, inter-events, seasonality) – aggregated to daily
- **Realistic ET:** Evaporation data are extracted from BOM areal potential ET maps
- **Realistic Rainfall-runoff model**: Simplified GR4J model (only production store)
- Evaluated on wide range of climatology's using data from 6 locations: Perth, Adelaide, Melbourne Sydney, Brisbane, Alice Springs
- Virtual data is available online (Thyer et al, 2015)

Li, J., M. Thyer, M. Lambert, G. Kuczera, and A. Metcalfe (2016), Incorporating seasonality into event-based joint probability methods for predicting flood frequency: A hybrid causative event approach, J Hydrol, 533, 40-52, http://dx.doi.org/10.1016/j.jhydrol.2015.11.038

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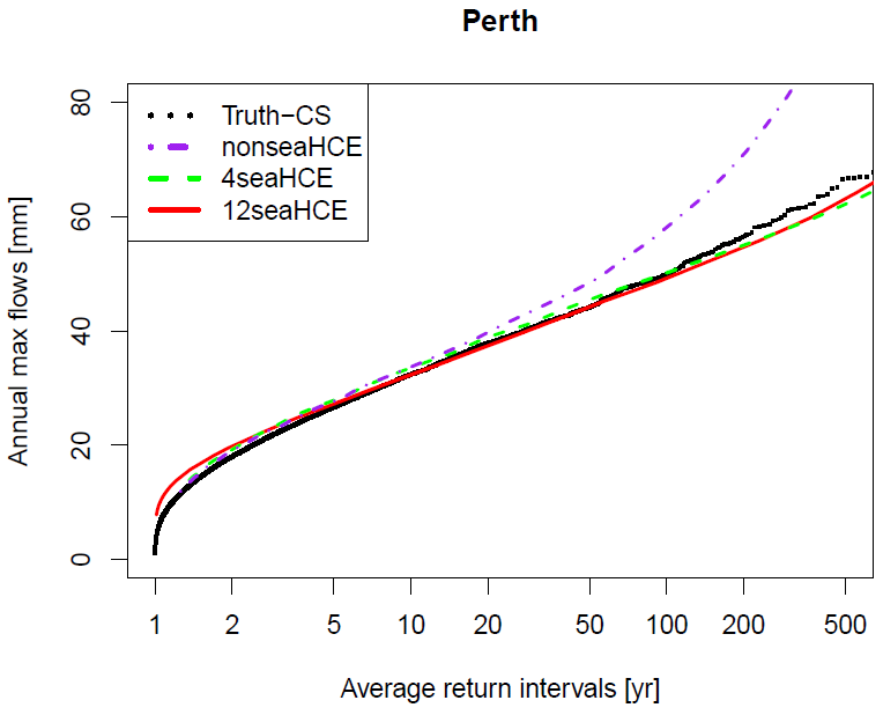
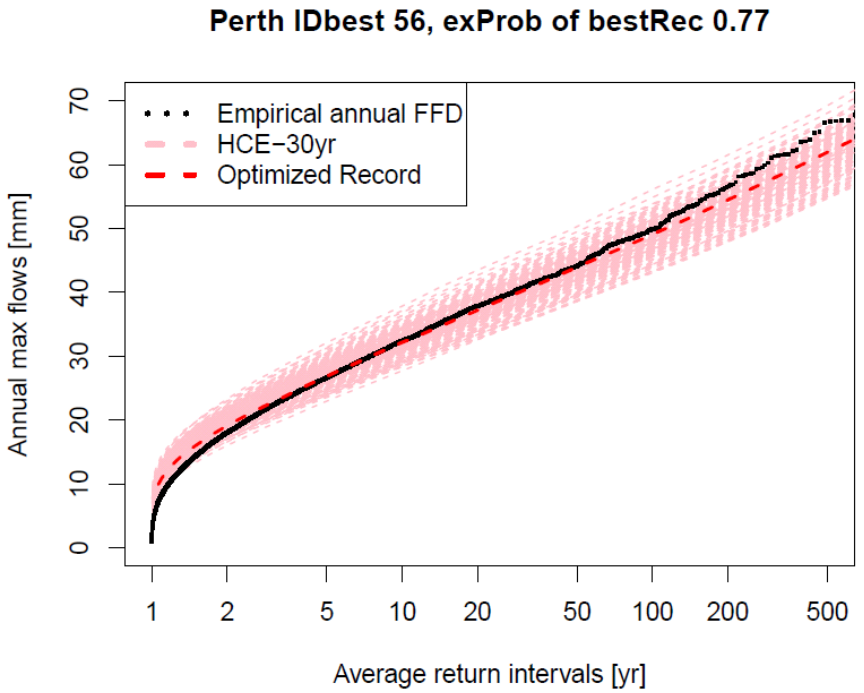
Seasonal HCE Case Studies

- Compared different approaches to seasonality
  - No seasonality, four seasons, 12 seasons





- Similar results for Adelaide and Melbourne
- **Mediterranean Climate** (winter rainfall, hot, dry summer)

  => strong seasonality in soil moisture

  => need seasonal event-based approach

Seasonal HCE Case Studies

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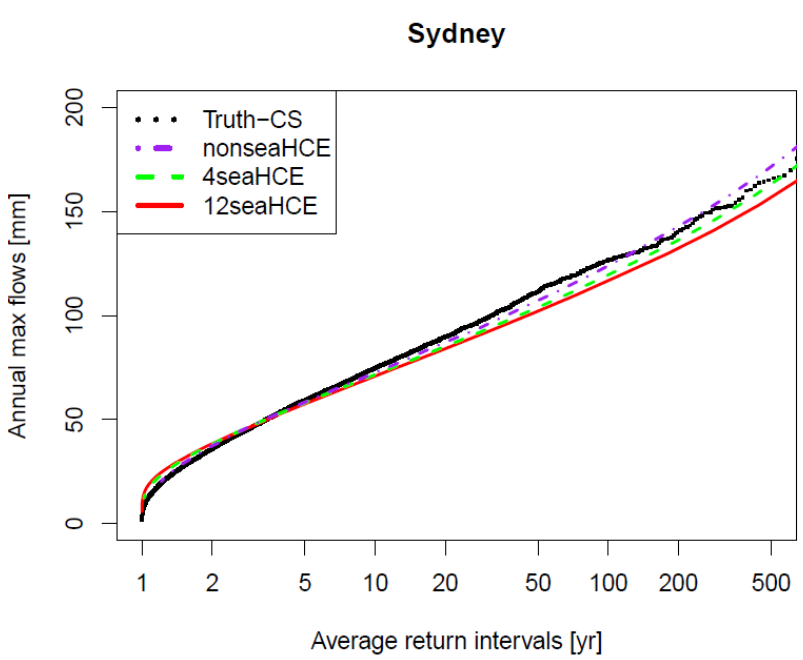
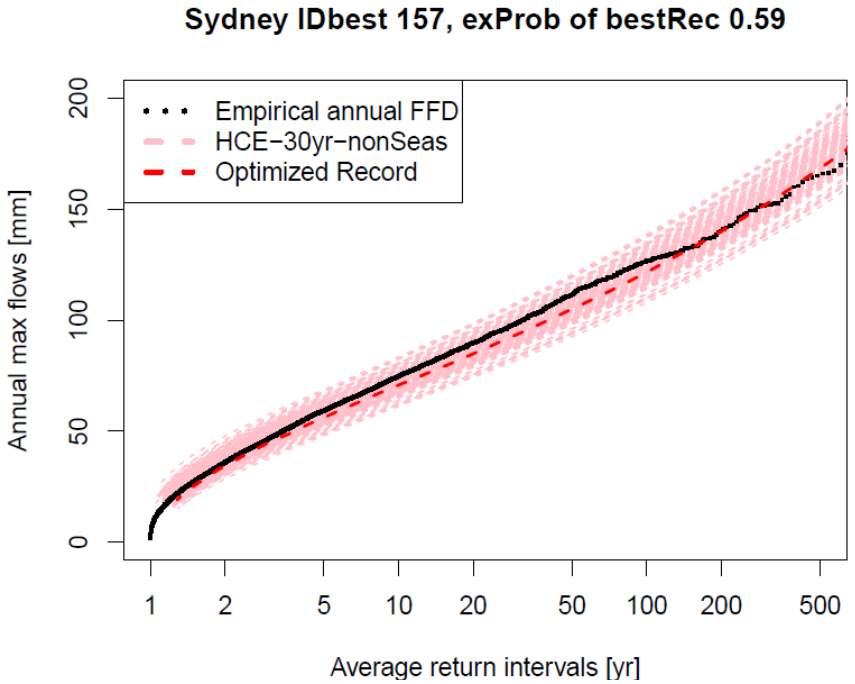
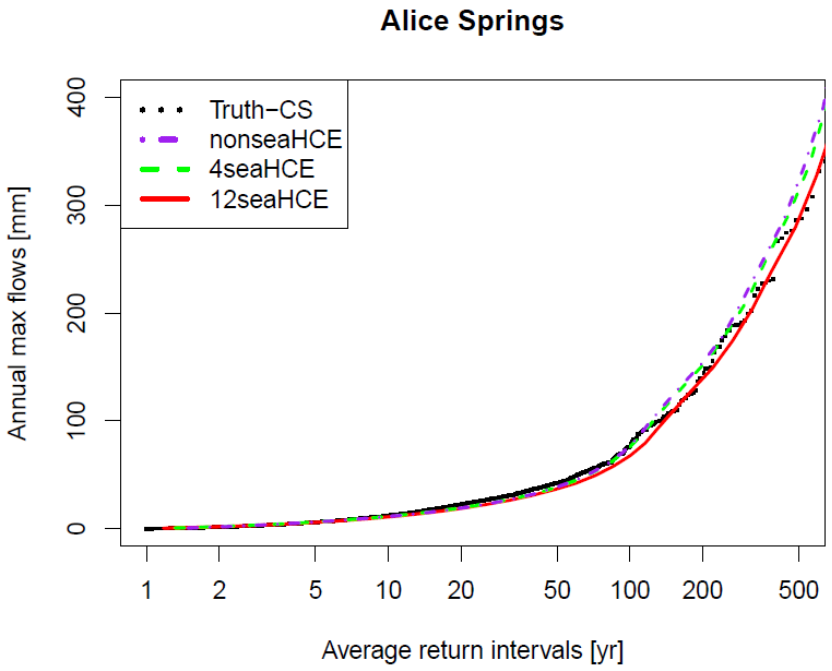


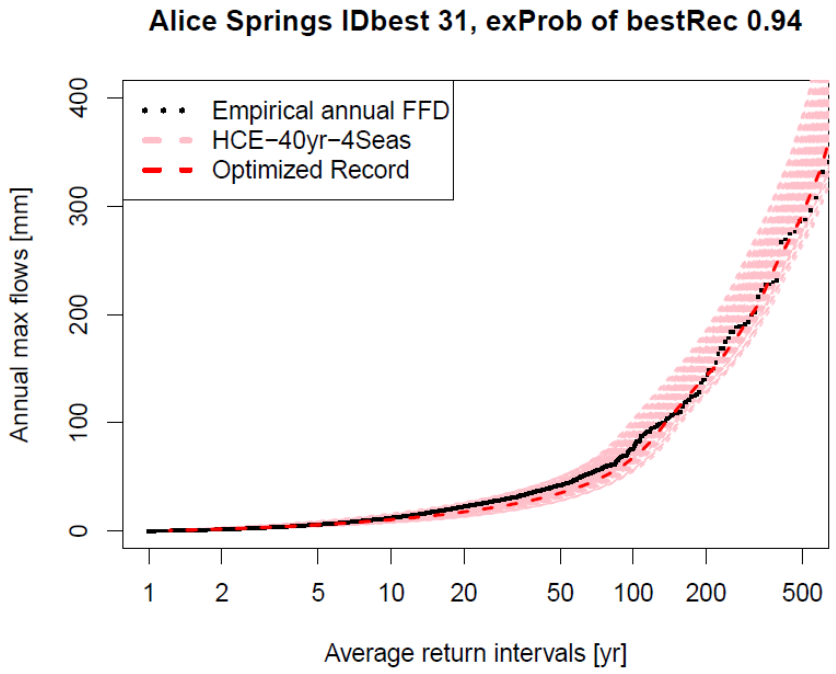


- Similar results for Brisbane
- **Sub-tropical climate**
- => reduced seasonality in soil moisture (cf Mediterranean)
- => no need for seasonal event-based approach

Seasonal HCE Case Studies

- Compared different approaches to seasonality
  - No seasonality, four seasons, 12 seasons

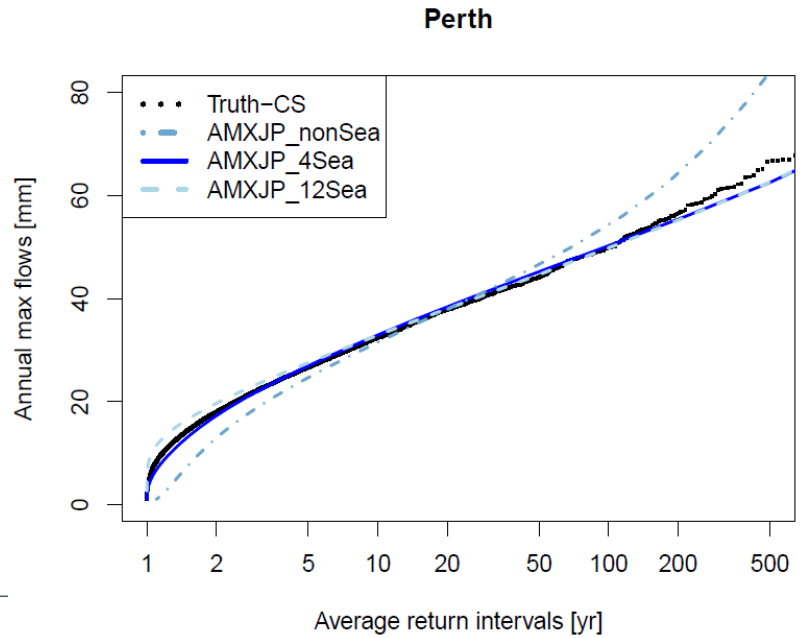




- Steep FFD, Floods dominated by extreme rainfall, soil moisture less important
- => no need for seasonal event-based approach

Case Studies – Results

- Existing event-based joint probability approaches (e.g. RORB)
- Similar results as HCE
- Locations with strong seasonal in SM, needed seasonal approach for accurate predictions.
- Implications for event-based approaches, eg. RORB



Future Development: HCE

- Current approach predicts annual maximum daily volumes
- Need to predict sub-daily flood hydrograph
  - Sub-daily rainfall generation
  - Temporal patterns etc.
- Current approach uses simplified single-store lumped rainfall-runoff models
  - need to handle multiple stores
  - Distributed models

Summary

- New approach for flood frequency estimation
  - Hybrid Causative Event (HCE) method
- Combines **accuracy** of continuous simulation with **efficiency** of event-based approaches
  - 100-1000 faster than CS
- Captures joint probability of flood generation processes using causative events **without need for AEP neutrality**
- Need for seasonality depends on climatology
  - Strong seasonality in soil moisture => need seasonality
- Future work to extend HCE to full hydrograph

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