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Climate change rainfall data algorithm for continuous modelling of stormwater

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Abstract: Continuous simulation modelling of stormwater pollutants & runoff is used in Australia to demonstrate compliance with Water Sensitive Urban Design (WSUD) guidelines, assess rainwater tank demand reliability, analyse annual volumetric flows and other engineering/environmental applications. A crucial input for this kind of modelling is the continuous Rainfall Data and the Potential Evapotranspiration (PET) data (typically at 6 minutes). Traditionally creating the continuous modelling data file faced multiple challenges with respect to acquiring, manipulating and packaging PET and rainfall data (text files) into a modelling, high quality useable file. To ensure appropriate PET and rainfall data usage in decision making and approvals, these challenges have been addressed and are not the subject of this paper. Taking a historical dataset as input, manipulation of continuous data modelling can be done via a new algorithm which will bring the Continuous Rainfall Data up to date with IFD data, while ensuring a user-specified Annual Mean rainfall. The algorithm proposed allows scaling of rainfall patterns for climate change based on latest Australian Rainfall & Runoff Guidelines and comparison of Intensity Frequency Duration (IFD) data against the mlb.

Keywords: *Stormwater Management; Continuous Rainfall Data; Stormwater Modelling; Software Tools; Continuous Modelling Climate Change,*

1. INTRODUCTION

Continuous simulation modelling of stormwater pollutants & runoff is used in Australia to demonstrate compliance with Water Sensitive Urban Design (WSUD) guidelines, assess rainwater tank demand reliability, analyse annual volumetric flows and other engineering/environmental applications. A crucial input for this kind of modelling is the meteorological template (mlb) file which includes Potential Evapotranspiration (PET) data and rainfall data. While many Authorities provide a meteorological template (Healthy Land and Water, 2018), until now no Climate Change algorithm has been proposed to ensure Climate Change adjustments are incorporated in the WSUD design. This leads to confusion in the Engineering and Consulting communities, further widening the gap between quantity and quality Stormwater Modelling. Fortunately, the Australian Rainfall and Runoff Manual has provided guidance on IFD Climate Change factors. By establishing relationship between local IFD frequencies and continuous data, we've developed an algorithm to enable climate change analysis for WSUD.

2. METHODOLOGY & RESULTS

2.1. Scale up all Rainfall

Definitions (Refined)

Let:

- $F = \{f_1, f_2, \dots, f_m\}$: Frequencies (AEPs), ordered descending (e.g., 10%, 5%, 2%, ...).
- $D = \{d_1, d_2, \dots, d_k\}$: Durations.
- $I_{\text{orig}}(f, d)$: Original IFD intensities.
- $I_{\text{new}}(f, d)$: New IFD intensities.
- r: A given rainfall amount.
- For fixed d, we search the **frequency bracket** (f_j, f_{j+1}) where:

$$I_{\text{orig}}(f_j, d) \leq r < I_{\text{orig}}(f_{j+1}, d)$$

$$I_{interp}(r,d) = I_{new}(f_j,d) + \frac{I_{new}(f_{j+1},d) - I_{new}(f_j,d)}{I_{orig}(f_{j+1},d) - I_{orig}(f_j,d)} \cdot \left(r - I_{orig}(f_j,d)\right)\, if\, r < 1\%AEP$$

$$I_{interp}(r,d) = r + \left(I_{new}(f_{min},d) - I_{orig}(f_{min},d)\right)\, if\, r \geq 1\%AEP$$

Scale every rainfall in the *.mlb so that the relationship between current rainfall and 2016 IFD is maintained in the climate change rainfall to climate change IFD. The IFD rainfall duration is matched to the timestep of the rainfall file (6 mins, 12 mins, etc.) but can be modified if needed (although not recommended). The IFD is downloaded from BOM for the exact Lat/Long where the adjustment is applied. This will scale up even the smallest rainfalls, increasing the yearly rainfall average. The scaling will be proportional to the change between original and climate change IFD. Detailed method is defined in the equations below.

2.2. Correction for Annual Average

The first step above will result in higher yearly rainfall averages. However, Climate Change science consensus suggests that Climate Change leads to more intense short-duration heavy rainfall events while the average rainfall decreases or stays the same (Bureau of Meteorology, 2025; CSIRO, 2020; CSIRO, 2024; IPCC, 2021).

One way to correct for increase, we shave all the rainfalls by a value chosen to bring the total average yearly rainfall back to a percentage of the "pre-scaling" value (the percentage value is currently 100%). This means the algorithm can handle *any* rescaling, with the default (not mandatory) set at 100. The difference in number of rainfall intervals and rainfall intensity between the original and the adjusted data is shown in Table 1.

Table 1 Key Statistics comparison before and after Climate Change Adjustment

Advanced Statistics	Original	Climate Change adjusted
Total MLB Days	1825	1825
Days with Rainfall	576	574
Total Timesteps	438,000	438,000
Total Timesteps with Rainfall	14,861	12,441
Median of Rainfall Timesteps mm/6mins	0.1600	0.1479
Average of Rainfall Timesteps mm/6mins	0.2124	0.2377

3. RESULTS

Table 1 shows one case of data adjustment. The results after adjustment show:

- A lowering of days experiencing rainfall, from 576 days to 574 days.
- A lowering of total number of rainfall intervals (at 6 minutes), from 14,861 to 12,441
- A lowering of the median rainfall value, from 0.160mm to 0.147mm
- A net increase of the average rainfall interval, from 0.2124 to 0.2377

The results above show that the algorithm, when scaling back is applied, provides two expectations: 1. Longer dry periods when maintaining the same average rainfall, shown in the number of rainfall intervals dropping by over 2,000; 2. Lower median value, as the rainfall volume from the majority of low rainfall events are lower. Table 1 shows the data complies with the Climate Change expectations. PET data is currently not subject to adjustment for two reasons: the PET impact on modelling is not high and currently these authors are not aware of any suggestions on how the PET will change over time, depending on socioeconomic scenarios and time horizons. The authors of this paper have contacted Australian CSIRO for further information and welcome suggestions on changes in the PET values based on predicted time horizons and socioeconomic scenarios (or other suggestions for that matter.

4. CONCLUSIONS

This paper and the implemented algorithm demonstrate a robust approach to solving problems of climate change predictions for continuous modelling. We expect this approach will generate modest increases in the requirements for WSUD assets, however an analysis of impacts is not in the scope of this paper.

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