CLIMATE CHANGE FOR WATER QUALITY (WSUD) AND QUANTITY

MIRCEA STANCU
GREGORY CHIAN

cleanstormwater.com.au

COVERED TOPICS

1. What is IFD?
2. Climate Change in AR&R
3. Climate Change Scenarios and Time Horizons
4. Climate Change for Continuous Data Algorithm
   - 4.1. Overlapping IFDs on Continuous Data
   - 4.2. Scaling Data on IFDs
   - 4.3. Trimming Total Average Rainfalls to Pre-scaling Values
   - 4.4. Interpretation of Final Results
5. How to Generate Climate Change MLB?
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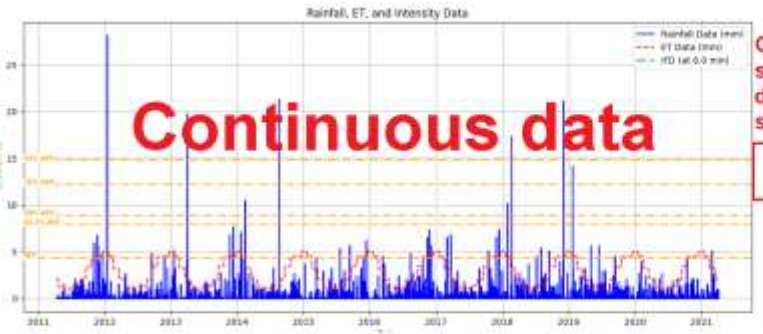
1. What is IFD?

- IFD stands for Intensity-Frequency-Duration.
- They exist because (historically) it was very difficult to use continuous modelling. Hence (through statistical analysis) Authorities decided to come up with a singular number for a storm that takes (say) 5 minutes and has a chance of 20% to happen in a year.
- These “design storms” are NOT REAL.
- In order to simulate reality, AR&R came up with:
  - Temporal patterns
  - “Pre-burst” rainfalls
  - Initial and Continuous loss (to also simulate Rainfall-Runoff soil performance + ET). Tony has some good info.

Used to calculate quantity Engineering: pipe sizes, OSD volumes, flooding-related stuff.

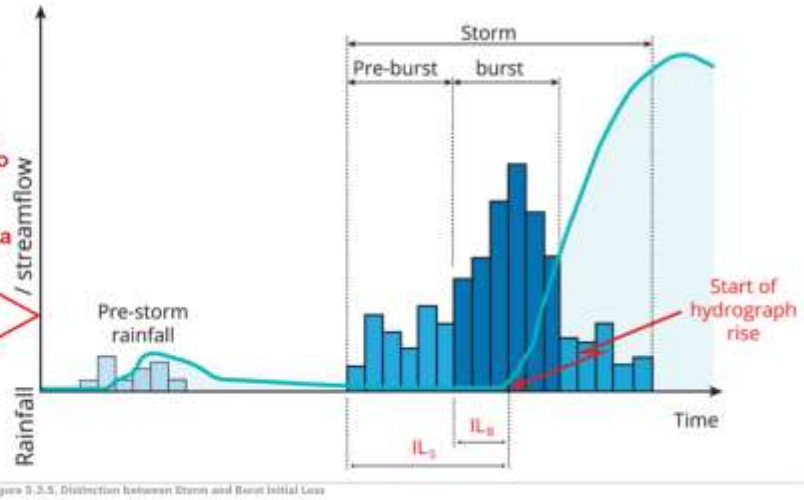


Gets distilled into one single number for any duration/probability storm

Table | Chart

Duration	Annual Exceedance Probability (AEP)						
	63.2%	50%#	20%+	10%	5%	2%	1%
1 min	90.0	103	147	181	219	273	321
2 min	77.0	87.7	127	158	193	241	283
3 min	69.2	78.9	114	141	172	221	265
4 min	63.3	72.2	104	129	156	198	235
5 min	58.6	66.7	96.5	118	143	180	213
10 min	43.4	49.5	70.6	86.9	105	130	152
15 min	35.2	40.1	57.2	70.4	84.7	106	123
20 min	29.9	34.1	48.6	59.9	72.1	90.2	106
25 min	26.2	29.8	42.6	52.5	63.3	79.4	93.2
30 min	23.4	26.6	38.1	47.0	56.7	71.3	83.8
45 min	18.0	20.5	29.4	36.3	43.9	55.4	65.4
1 hour	14.9	17.0	24.2	30.0	36.2	45.8	54.1
1.5 hour	11.3	12.9	18.4	22.7	27.4	34.5	40.7
2 hour	9.32	10.6	15.0	18.5	22.3	27.9	32.8

Manipulate the number back so it kinda resembles Continuous data



Statistical analysis is applied to continuous data to generate one single [not real] storm number, after which further data manipulation is employed to make that number behave as if it was continuous data. Not kidding.

2. Climate Change in AR&R

- Shifting to a risk-based approach to design, not if but when
- Recommends climate change considerations to drainage design to ensure resilience
- With WSUD requirements becoming more prevalent, consistent drainage design has to consider both quantity and quality. But how do we do this?

Quantity:
AR&R Book 1 Chapter 6 has laid the groundwork **for event-based rainfall modelling** (using BOM IFDs) which is used **for stormwater quantity/hydrological/flood analysis**.

Quality:
AR&R has no clear recommendation on climate change adjustments for **continuous rainfall modelling in stormwater quality.**

> Although continuous simulation approaches can be adapted to use climate-adjusted input timeseries (rainfall and potential evapotranspiration), further research is required to develop robust and practical methods to generate these climate-adjusted inputs into continuous simulation models, and applications will generally require the development of individualised solutions. As a pragmatic minimum, it is recommended that extreme rainfalls in the timeseries used for continuous simulation be scaled to reflect the recommendations for incorporating climate change into Intensity-Frequency-Duration curves (**Section 6.4.1**), with the remaining rainfalls adjusted to reflect projections of the mean seasonal or annual rainfall for the location of interest. Suitable account will also need to be given to adjusting evaporative demand inputs.

3. Climate Change Scenarios and Time Horizons

Climate Change Adjustment Based On 2016 IFD Data Baseline (Recommended)

Climate Scenario	Near-term		Medium-term		Long-term			
	2030	2040	2050	2060	2070	2080	2090	2100
SSP1-2.6	1.2	1.3	1.4	1.5	1.5	1.5	1.5	1.4
SSP2-4.5	1.2	1.4	1.7	1.9	2.1	2.2	2.4	2.5
SSP3-7	1.2	1.5	1.8	2.2	2.5	2.9	3.3	3.6
SSP4-8.5	1.3	1.6	2.1	2.5	3	3.5	4.1	4.5

3. Climate Change Scenarios and Time Horizons

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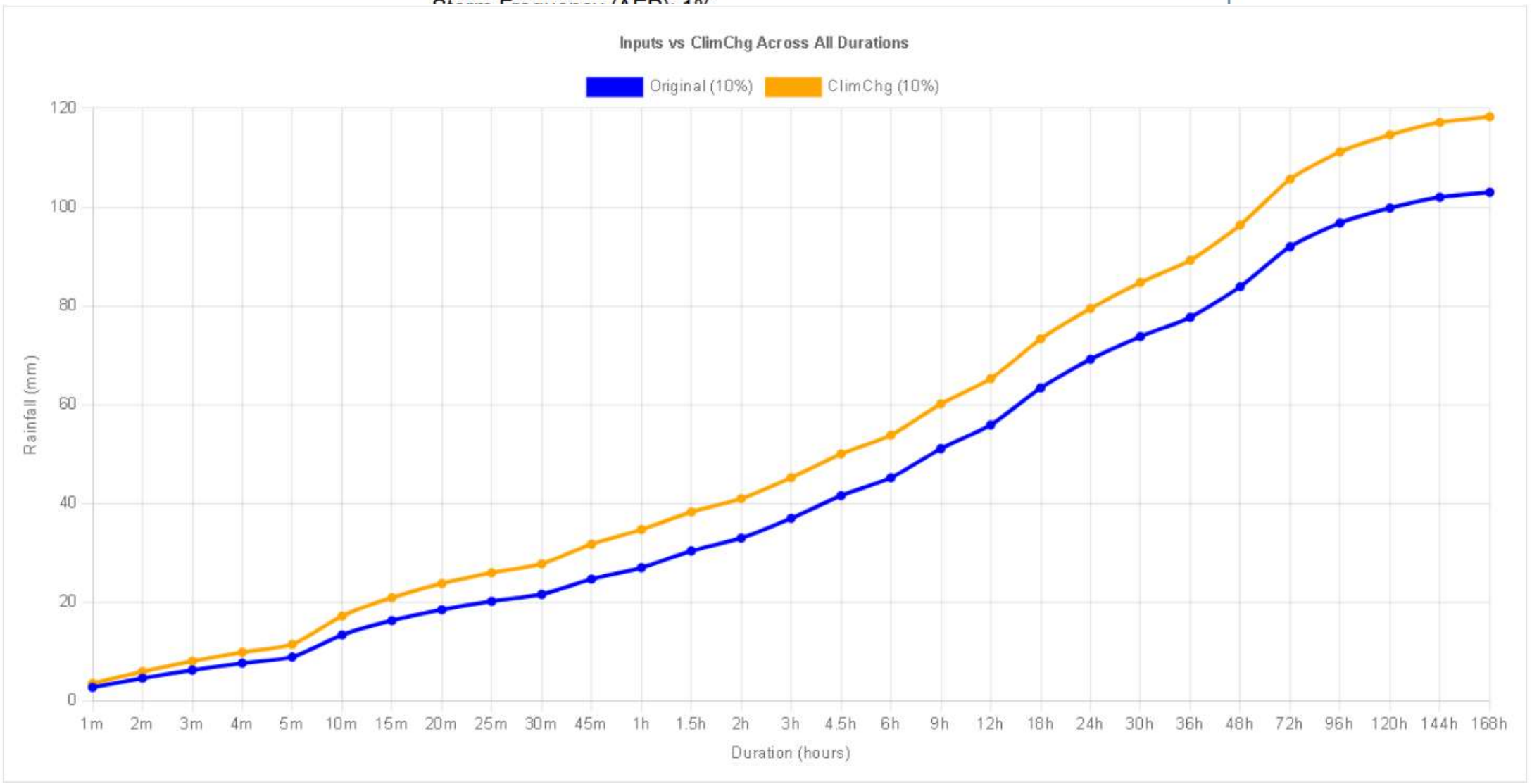
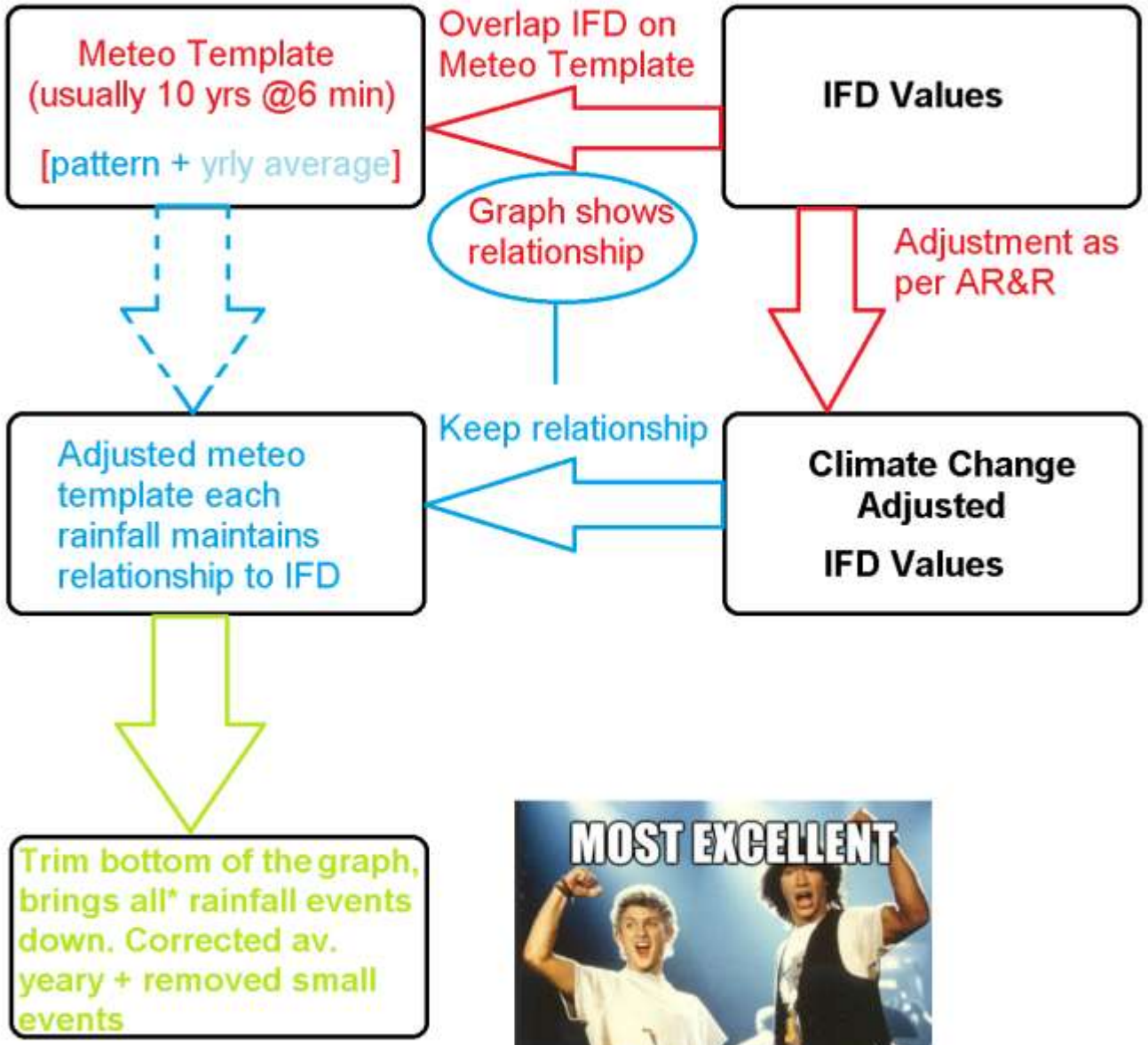


4. Climate Change for Continuous Data Algorithm



4.1. Overlapping IFDs on Continuous Data

Step 1: Establish a relationship between IFD intensities and Meteo Template – overlap IFD on continuous data graph

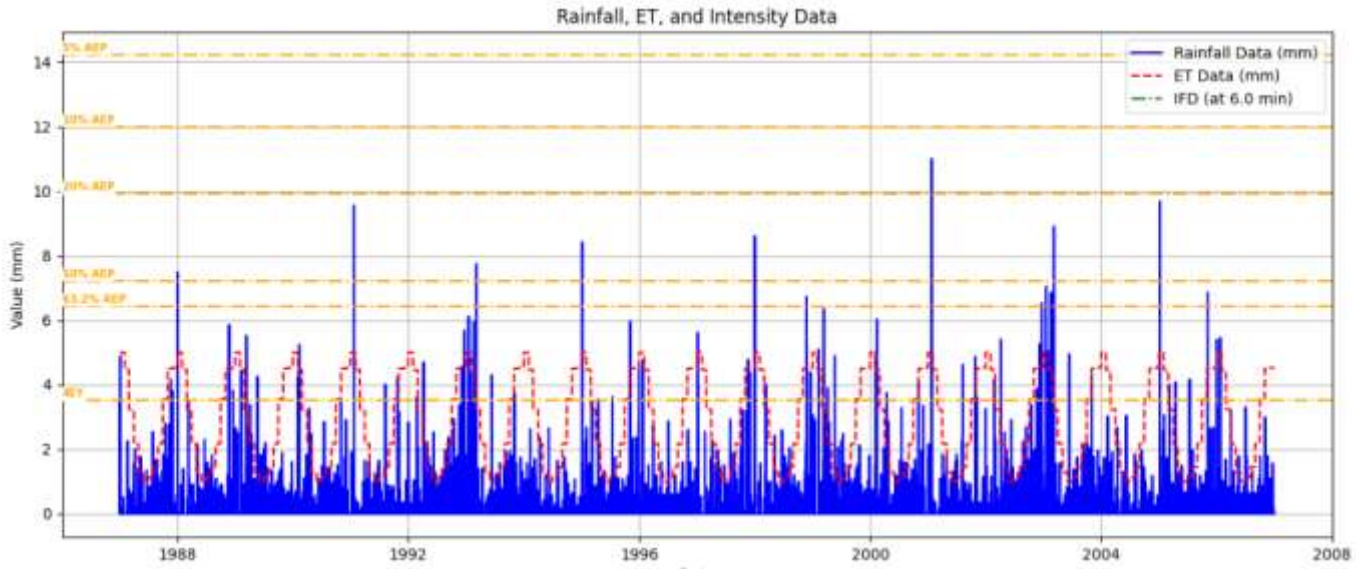
IFD Data (Event Based Modelling used for flooding, quantity, OSD)

Table | Chart

Unit: mm/h

	Annual Exceedance Probability (AEP)						
Duration	63.2%	50%#	20%*	10%	5%	2%	1%
1 min	90.0	103	147	181	218	273	321
2 min	77.0	87.7	127	158	193	251	303
3 min	69.2	78.9	114	141	172	221	265
4 min	63.3	72.2	104	128	156	198	235
5 min	58.6	66.7	95.5	118	143	180	213
10 min	43.4	49.5	70.6	86.9	105	130	152
15 min	35.2	40.1	57.2	70.4	84.7	106	123
20 min	29.9	34.1	48.6	59.9	72.1	90.2	106
25 min	26.2	29.8	42.6	52.5	63.3	79.4	93.2
30 min	23.4	26.6	38.1	47.0	56.7	71.3	83.8
45 min	18.0	20.5	29.4	36.3	43.9	55.4	65.4
1 hour	14.9	17.0	24.2	30.0	36.2	45.8	54.1
1.5 hour	11.3	12.9	18.4	22.7	27.4	34.5	40.7
2 hour	9.32	10.6	15.0	18.5	22.3	27.9	32.8
3 hour	7.05	8.00	11.3	13.8	16.5	20.5	23.9
4.5 hour	5.33	6.05	8.47	10.3	12.2	14.9	17.1
6 hour	4.36	4.95	6.89	8.30	9.76	11.8	13.4
9 hour	3.28	3.73	5.15	6.14	7.14	8.47	9.51
12 hour	2.68	3.04	4.18	4.95	5.71	6.70	7.47
18 hour	1.99	2.27	3.10	3.65	4.16	4.85	5.36
24 hour	1.61	1.83	2.50	2.93	3.33	3.87	4.27
30 hour	1.36	1.55	2.11	2.47	2.80	3.26	3.60
36 hour	1.18	1.35	1.84	2.15	2.43	2.83	3.14
48 hour	0.937	1.07	1.47	1.71	1.94	2.28	2.54

Meteo Templates -MLB (Continuous Simulation Modelling used in stormwater quality)



4.2. Scaling Data on IFDs

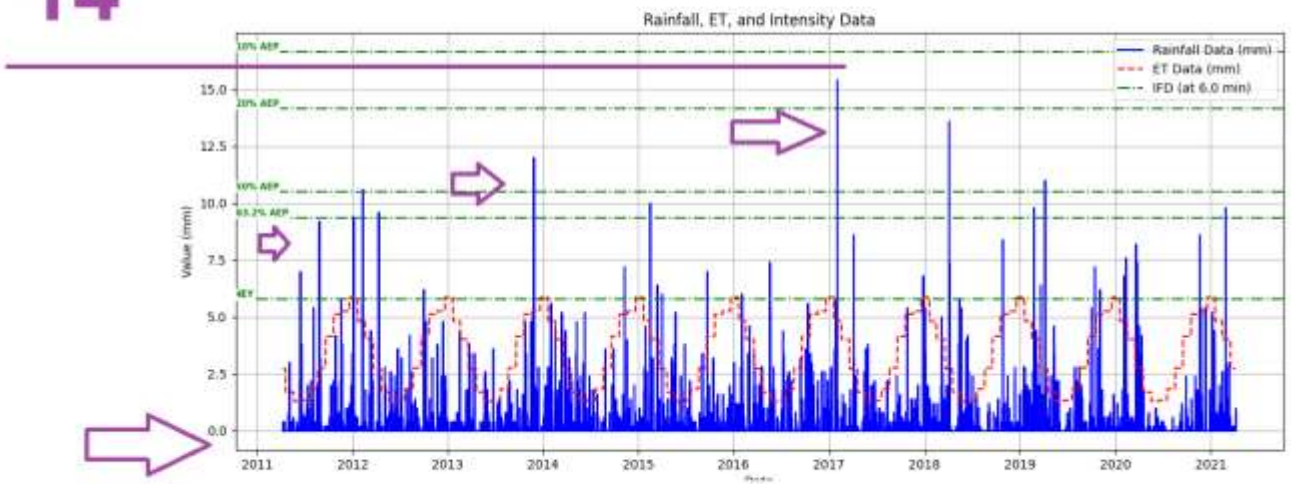
Step 2: Slice the continuous graph at every IFD value, and raise (or lower) all the rainfall in that "slice" proportionally

On the left, the original

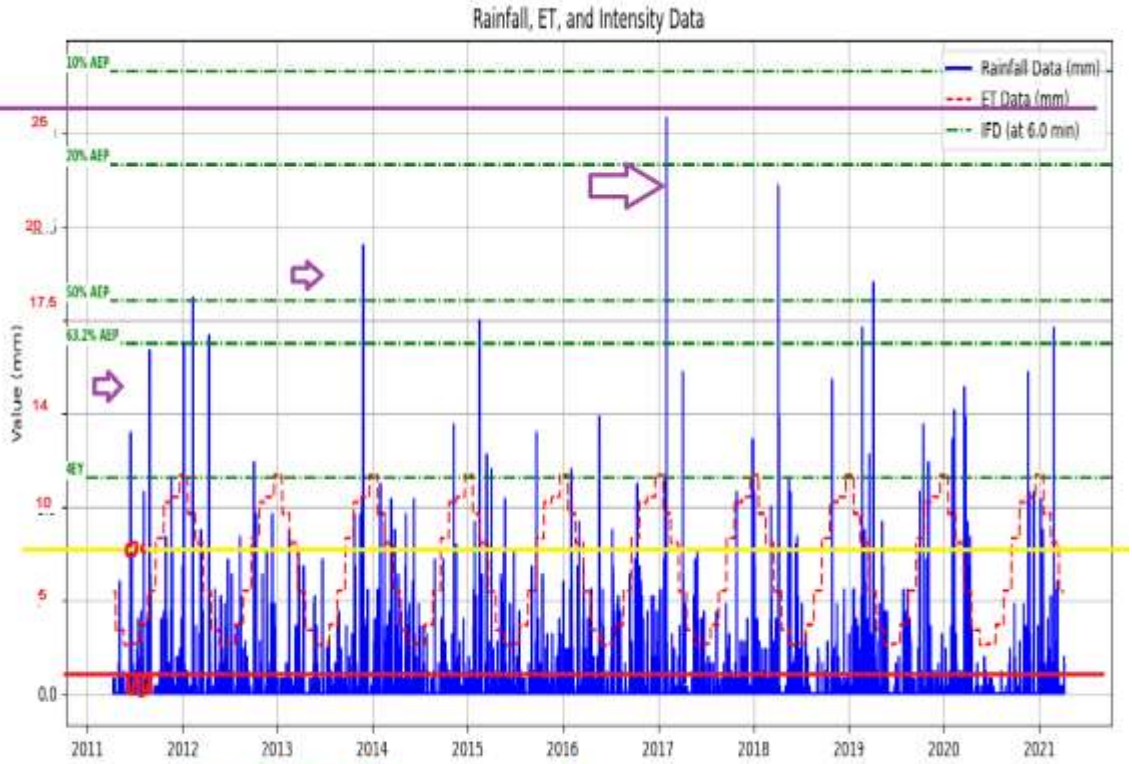
On the right, the graph when all intervals are adjusted to the IFD

27

14



1,000 mm/yr



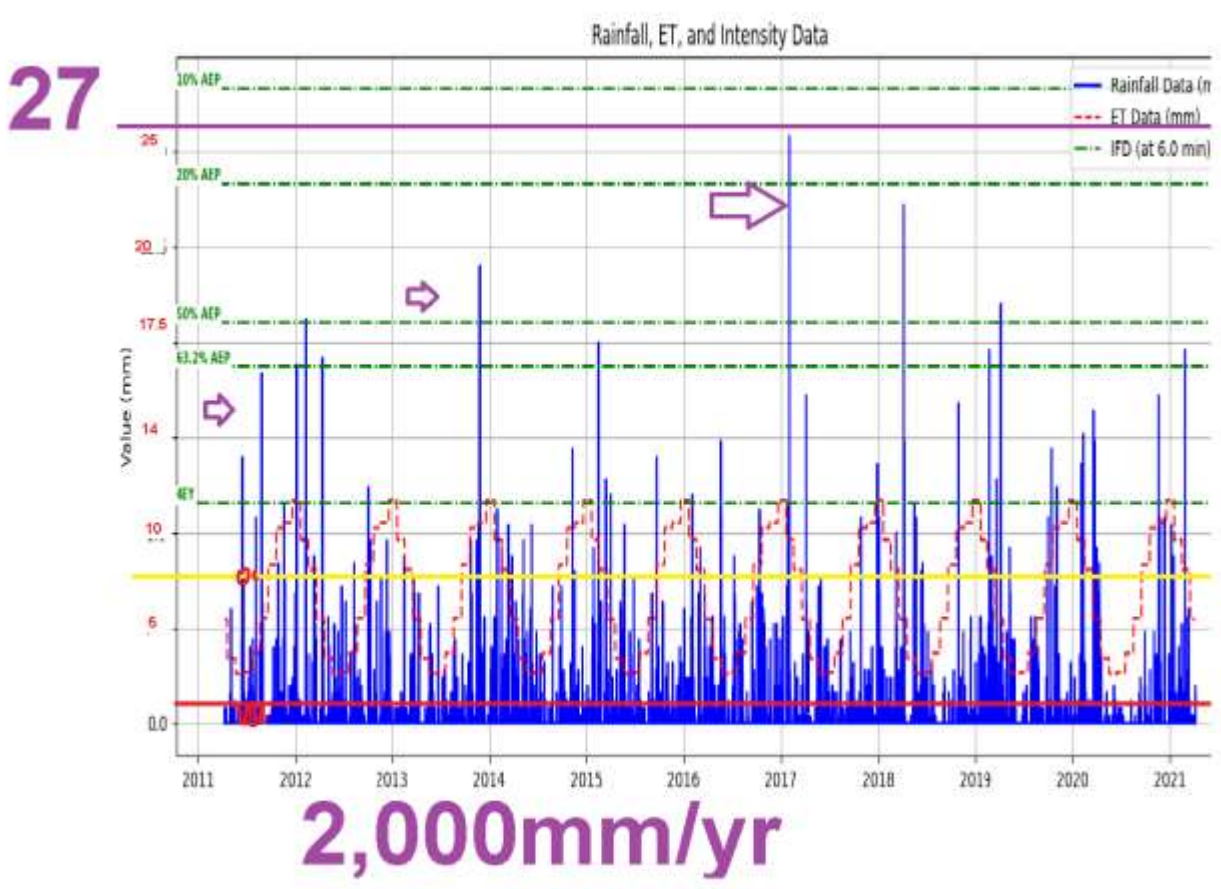
2,000mm/yr

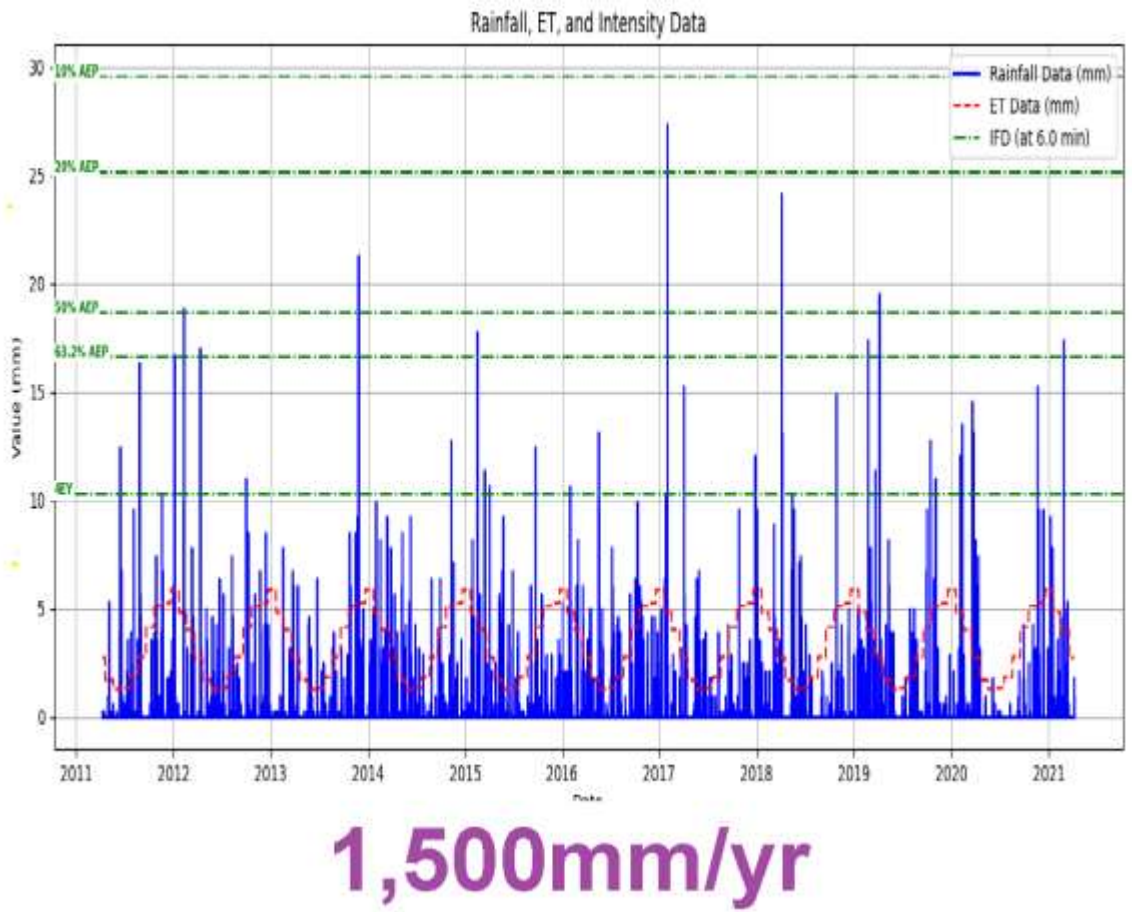
4.3. Trimming Total Average Rainfalls to Pre-Scaling Values

Step 3: Trim the bottom of the graph, so the total average yearly rainfall is brought to the number required

On the left, IFD-adjusted but “un-trimmed” graph

On the right, the lower rainfalls trimmed (everything* under the red line, removed)





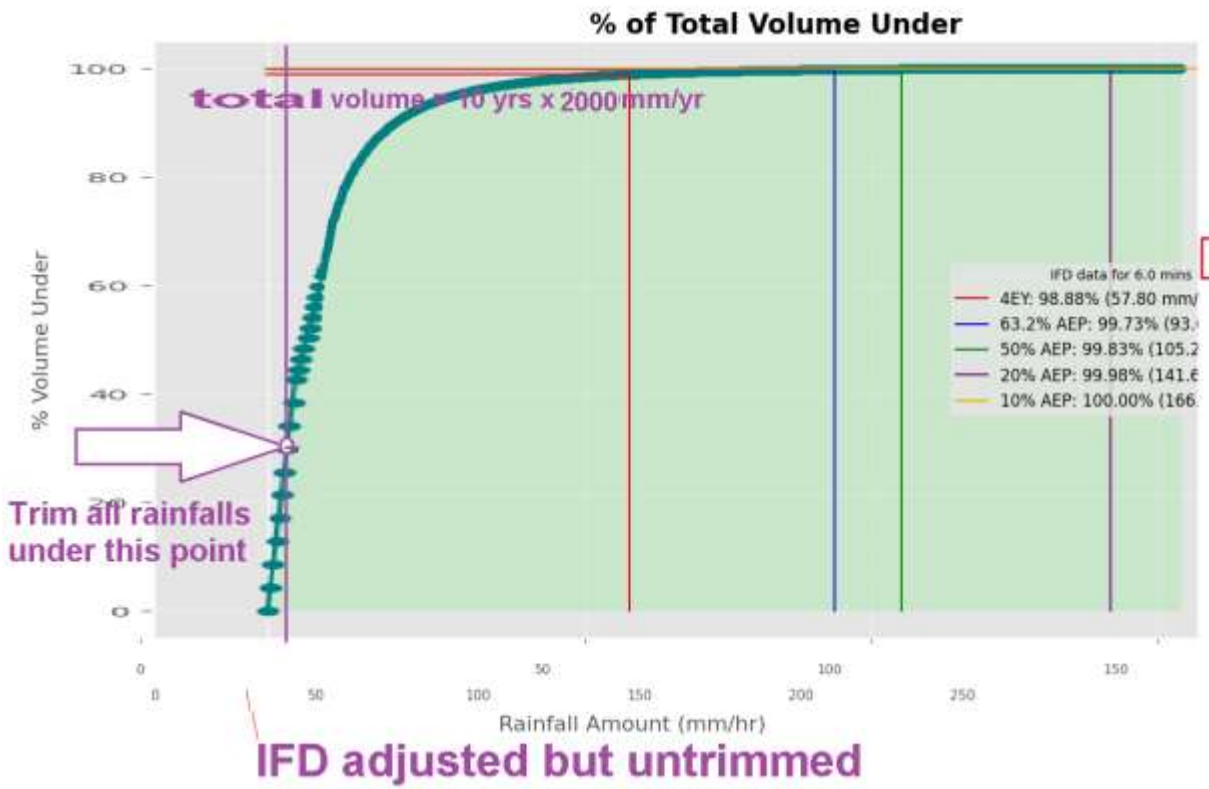
*All events with a value of 80% 4EY or higher are spared from trimming, but this can be adjusted if needed

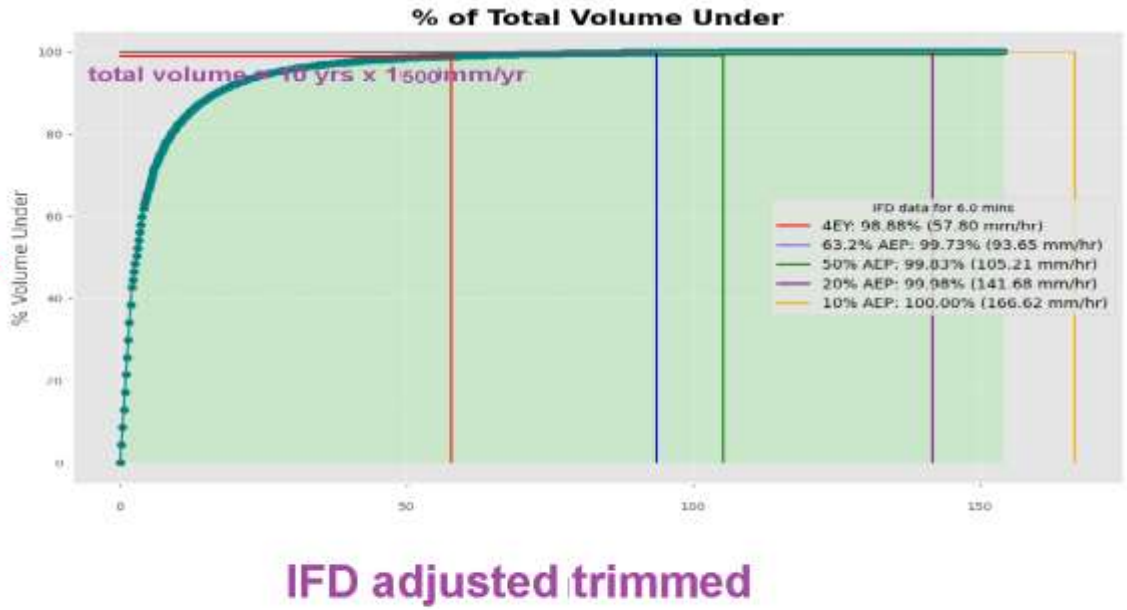
4.3. Trimming Total Average Rainfalls to Pre-Scaling Values

Step 3 (b): Another way to represent the trimming:

On the left, IFD-adjusted but "un-trimmed" graph

On the right, the lower rainfalls trimmed (everything* left of purple line, removed)



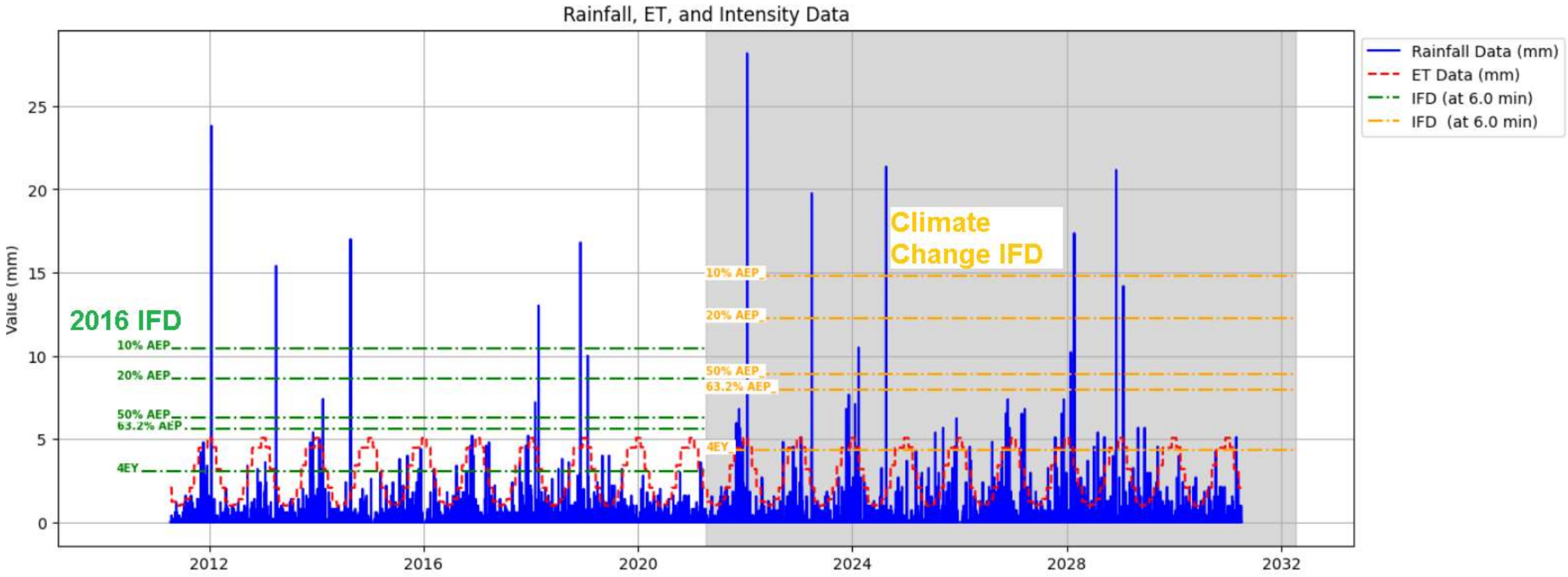


4.4. Interpretation of Final Results

Final Result: white background, initial graph. Grey background, IFD adjusted and Trimmed graph.

On the left, initial graph

On the right, climate change adjusted graph



4.4. Interpretation of Final Results

Interesting findings

Advanced Statistics	Original	Climate Adjusted
Total MLB Days	3650	3650
Days with Rainfall	1451	1449
Total Timesteps	876000	876000
Total Timesteps with Rainfall	15922	15902
Median of Rainfall Timesteps mm/ 6 mins	0.2000	0.1345
Average of Rainfall Timesteps mm/6 mins	0.3567	0.3572

Slightly lower no of days with rainfall

Slightly lower no of events (any 6 min experiencing rainfall)

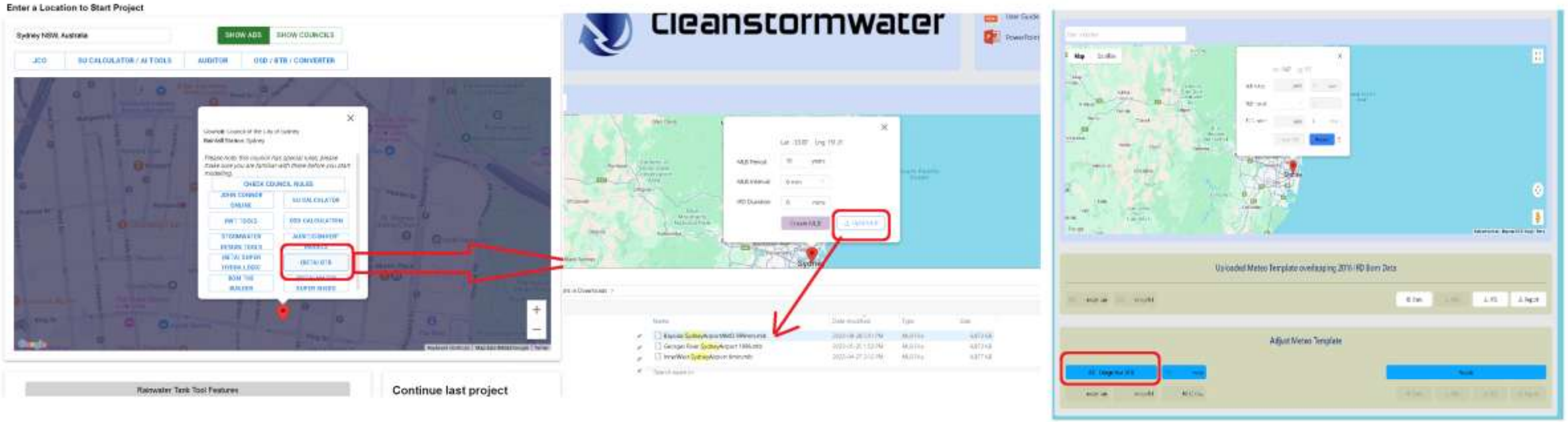
32% lower event median (drier, 50% of events are under this value)

Slightly higher average (indicating more extreme events)

Overall, this is consistent with prevalent science expecting more extreme events and drier climate.

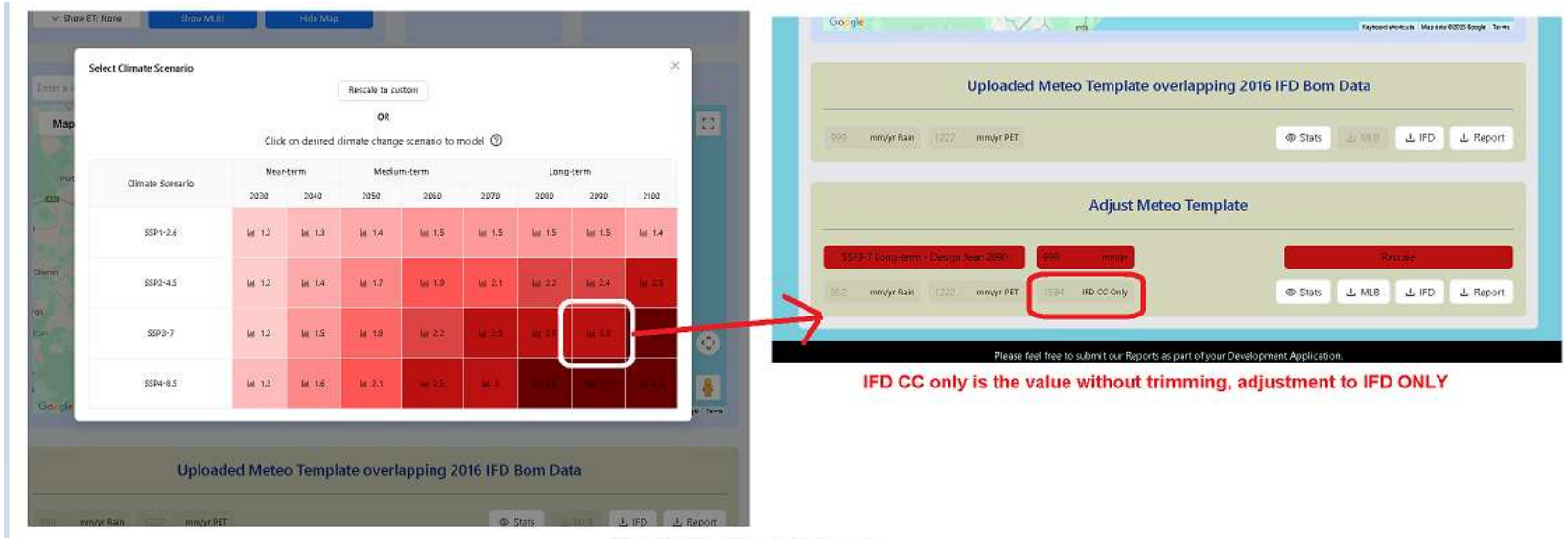
5. How to generate climate change MLB?

How can YOU do this analysis: Option 1, upload an existing meteo template (say, like one provided by Council)

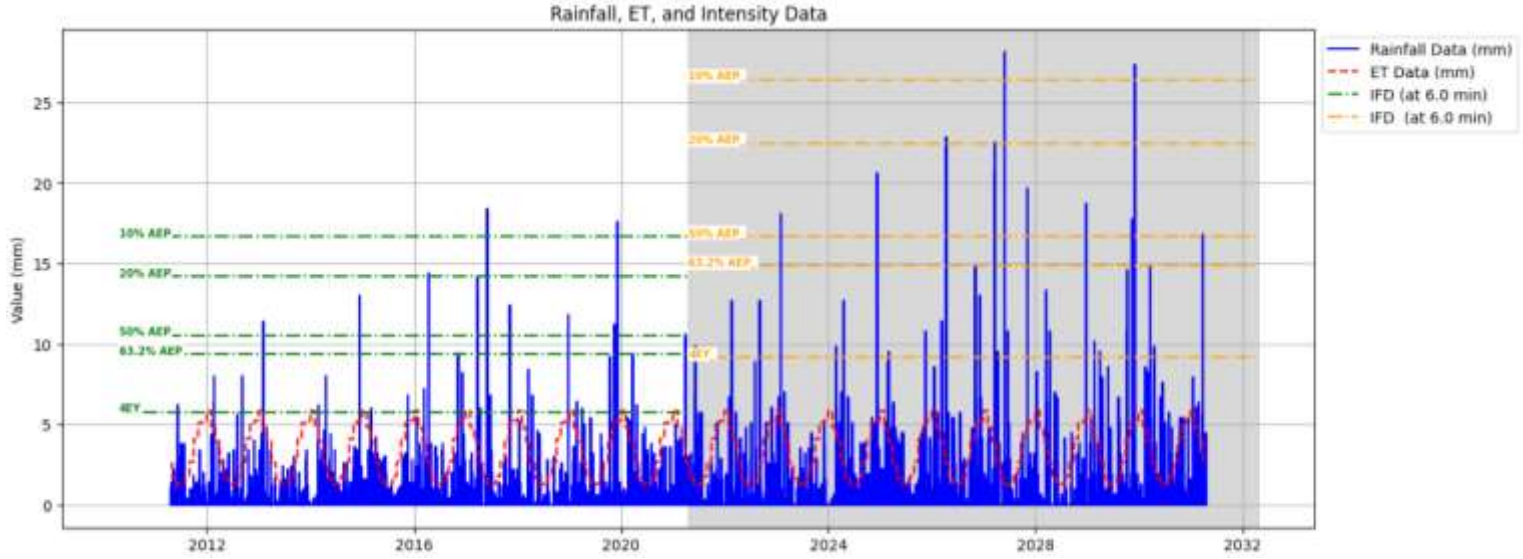


5. How to Generate Climate Change MLB

Could change the final total yearly average if needed

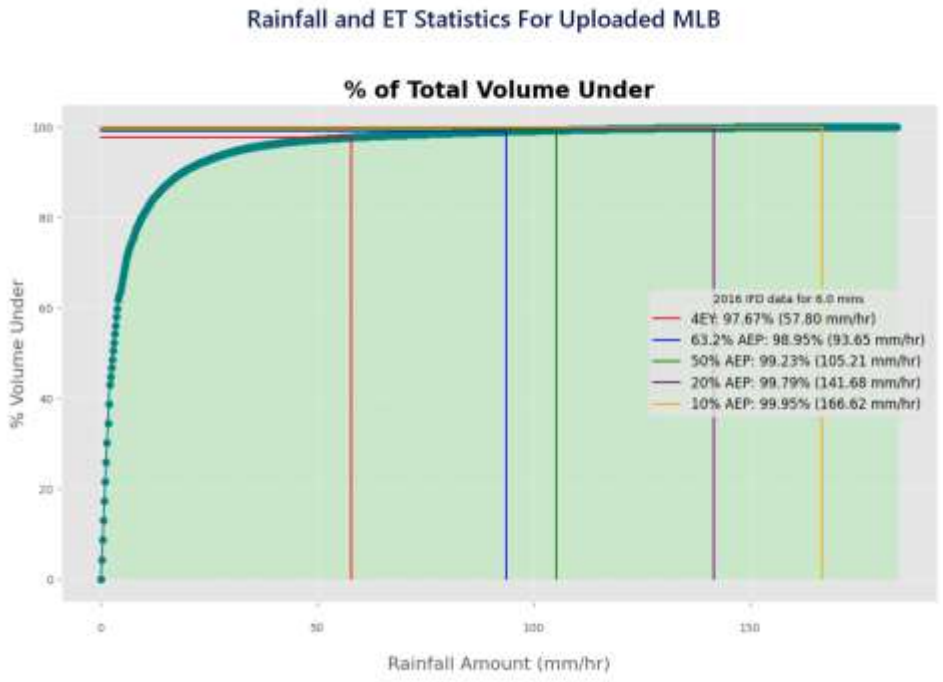


IFD CC only is the value without trimming, adjustment to IFD ONLY

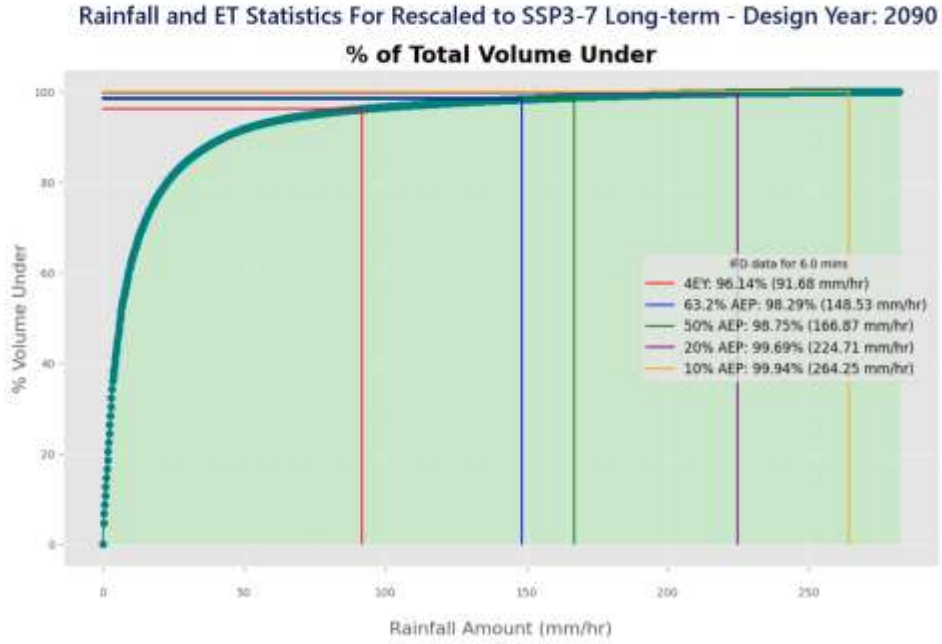


5. How to Generate Climate Change MLB

Another way to see the difference



Advanced Statistics	Original	Climate Adjusted
Total MLB Days	3650	3650
Days with Rainfall	1424	1415
Total Timesteps	876000	876000
Total Timesteps with Rainfall	21458	21440
Median of Rainfall Timesteps mm/ 6 mins	0.2000	0.0214
Average of Rainfall Timesteps mm/6 mins	0.4654	0.4439



Overall, this is consistent with prevalent science expecting more extreme events and drier climate.

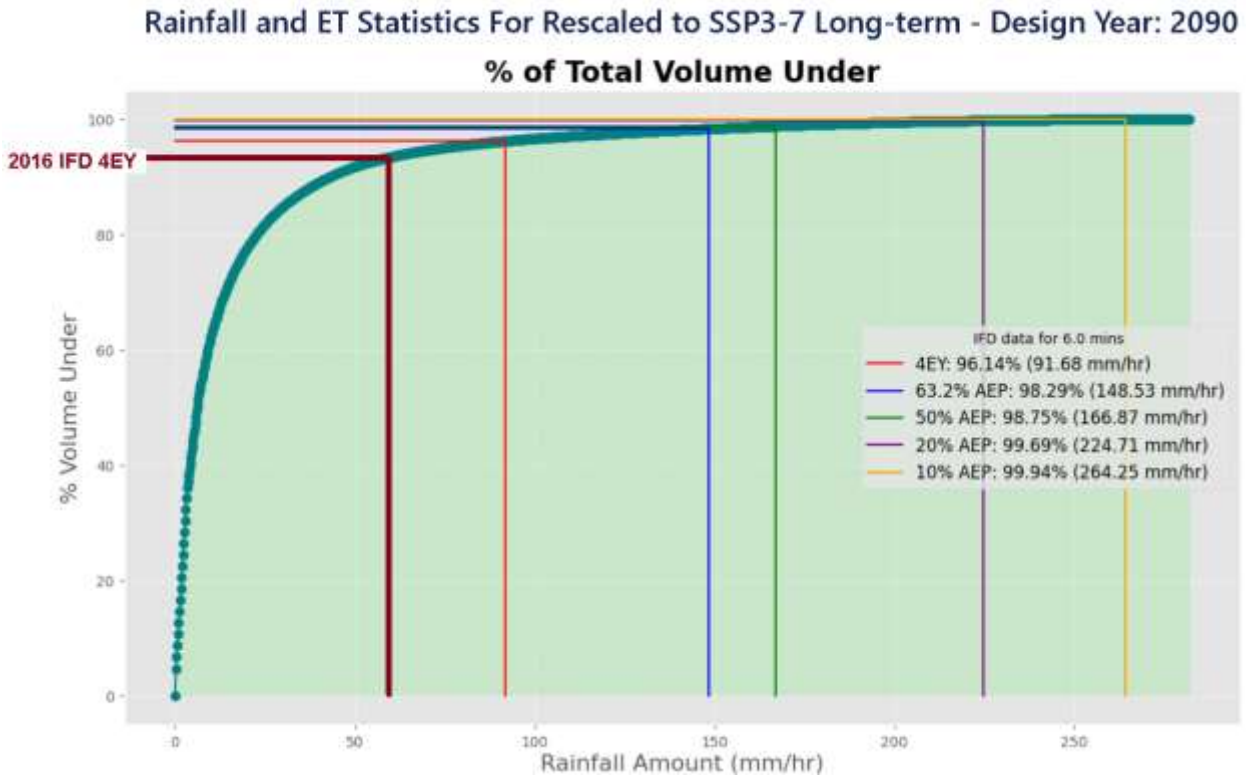
Pre-Webinar Questions?

6. Questions

SIZING OF TREATMENT DEVICES

Are there any implications for sizing of treatment devices resulting from climate change at the WSUD design stage?

Answer: The climate adjusted MLBs tend to be peakier. This means (theoretically), a GPT with higher high flow bypass is required to treat the same volume of water. Constructed devices like bioretentions might increased in size. RWTs may lose reliability due to lower number of intervals with rainfall. To combat this, we may have to increase RWT size to meet 80% reliability. The green graph may shed some light – in terms of % of total volume under a certain mm/hr number.



I am using IFD in this context ONLY as a proxy for volumes under a certain rainfall value

PLEASE ALWAYS VERIFY THE MODELLING **AFTER** YOU DECIDE THE HIGH FLOW BYPASS [say BY USING AN IFD CALCULATION].

WSUD **MUST** BE VERIFIED BY MODELLING AFTER SIZING THE PIPES GOING INTO THE DEVICE.

Can't stress this enough.

6. Questions

Sediment Loads

Is it expected that catchments subjected to frequent prolonged dry spells with reduced plant growth will produce a greater sediment load in the surface runoff than current design practices allow for and if so, is there any recommendation to make allowance for the increased sediment load based on research?

Answer:
Taking current Guidelines. Melbourne Guidelines by our good friends at MW (for example) show rainfall variations between ~450mm/yr and 1100+mm/yr. Pollutant generation does NOT change in their Guidelines pollution generation nodes.
Similarly, AFAIK, neither Healthy Land and Water, nor NSW Guidelines consider any differences in sediment loading based on meteo template delta. This suggest that current paradigm does not consider rainfall variation to be a significant factor in pollutant generation. AFAIK, landuse is the most important factor for pollutant generation.
This bein said, if the industry finds a relationship, we can easily facilitate industry wide adoption and implementation of said relationship through automation of an appropriate algorithm. So far, as far as we know, there is no guidance yet on adjustment of sediment loading for meteo template variation (and implicitly climate change) in any of the WSUD modelling guidelines. If there is please let us know.

Design of WSUD Systems

Does the changes to AR&R influence design of WSUD systems?

Answer: We expect so, especially for dual use devices. For others, modelling will tell. For example, detailed swale design requires we ensure swale parameters can convey the design flows. If design flows increase due to climate change, swale parameters would have to be checked to ensure it can still convey flows.

6. Questions

Integrating Quality and Quantity
Would like to understand how you integrated CC Factors into the SW quality environment as well as the SW quantity environment (understand the quantity aspect).

Answer: This is done by establishing a relation ship between IFD intensity bands (50%, 20%, 10% etc.) and the % of rain that falls under the cumulative curve for intensities in the meteo template. Hopefully the presentation so far has answered.

Manipulation of IFDs
Have concerns about 'manipulating' IFDs

Answer: The algorithm used establishes a relationship between the meteo template and the IFD. Then, the **manipulation is performed on the meteo template** (not the IFD). IFDs are as per BOM & AR&R.

Design of WSUD Systems
What software will this CC quantity-quality integration require, what is the cost, and what are the ongoing commitments ($$)?

Answer:
1. Bom the Builder – (Beta) currently is free to generate any meteo template with climate change adjustment.
2. John Connor Online – Selection of climate change adjustment is applied to authority/council specific meteo templates (example: Brisbane, Gold Coast, Sydney, Liverpool, Bendigo, etc.). The Entire Eastern Seaboard (TAS & SA included). These are then used in JCO model runs (each model run is $0.069) or adjusted mlb can be downloaded for $4.20

Thank You Everyone!

Mircea Stancu

mircea@cleanstormwater.com.au

Gregory Chian

greg@cleanstormwater.com.au

www.stormupdated.com.au