Implementing multi century hourly stochastic precipitation using CMIP6 - A trade-off approach

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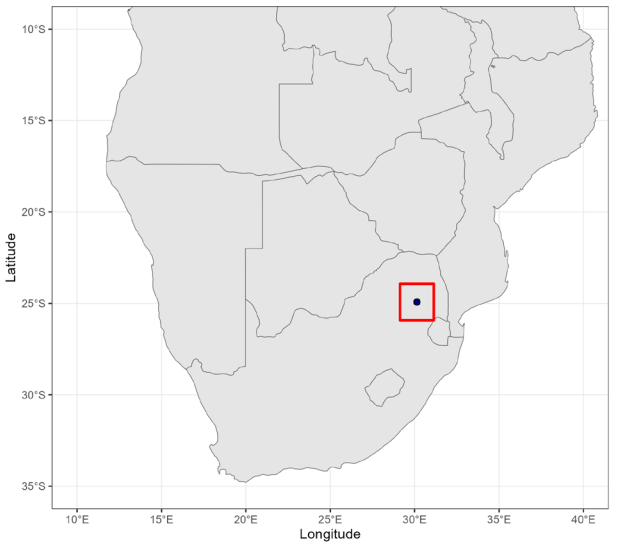
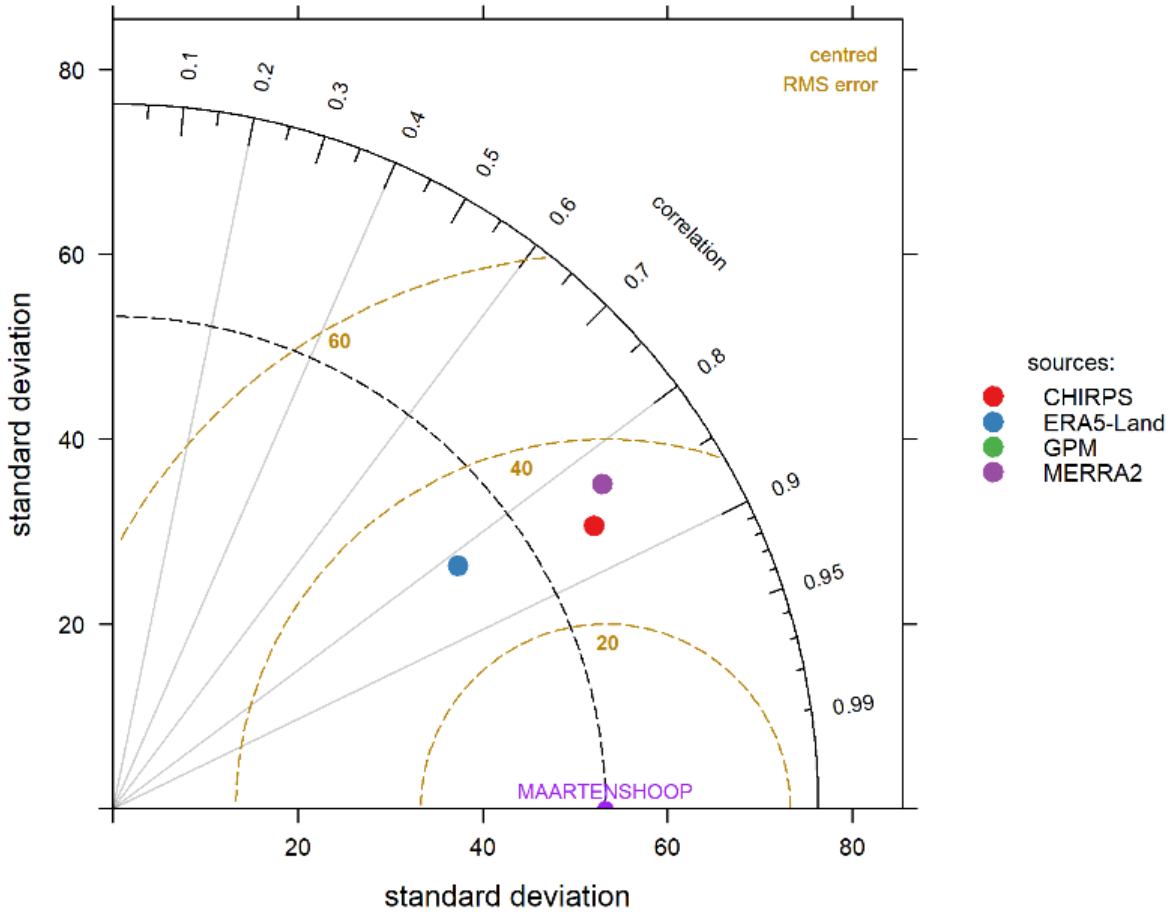
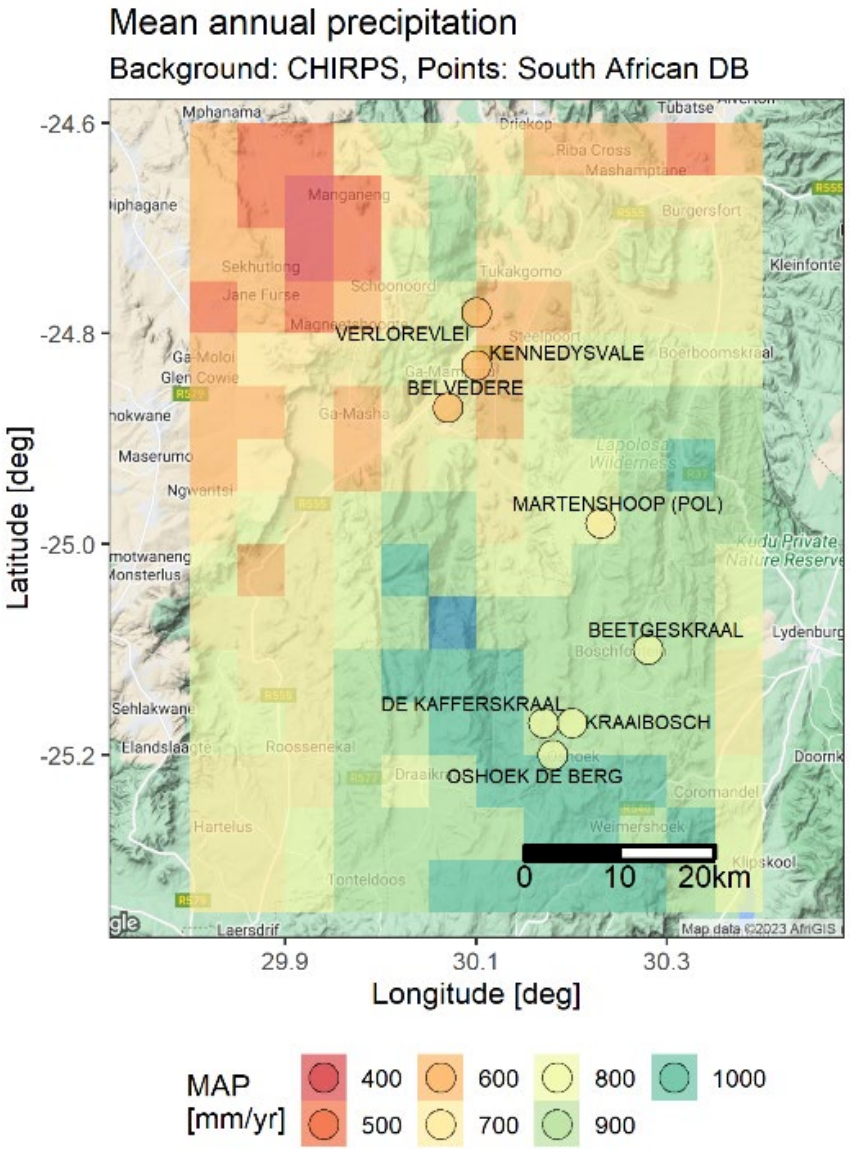
Introduction

Objective	▪ Landform design requirements => 300 yrs. 30 min. precipitation in South Africa (limited records)
Problem	▪ Current climate change models only provide projections up until the year 2100. ▪ Most of GCM are at daily scale. SA does not great historical records.
Study Focus	▪ South Africa, open source precipitation available 2000. ▪ Limitations for historical records and support projection under climate change.
Methodology	▪ Baseline Meteorology for precipitation ▪ Stochastic precipitation model ▪ Global circulation model (GCM)



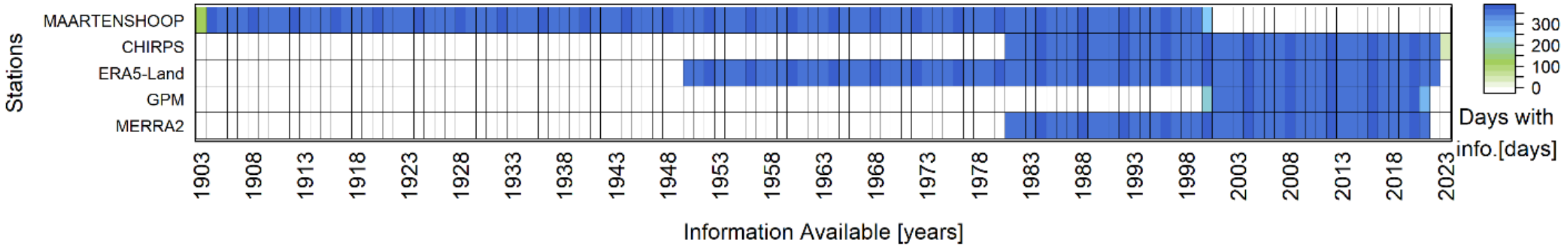
Climatic Influence





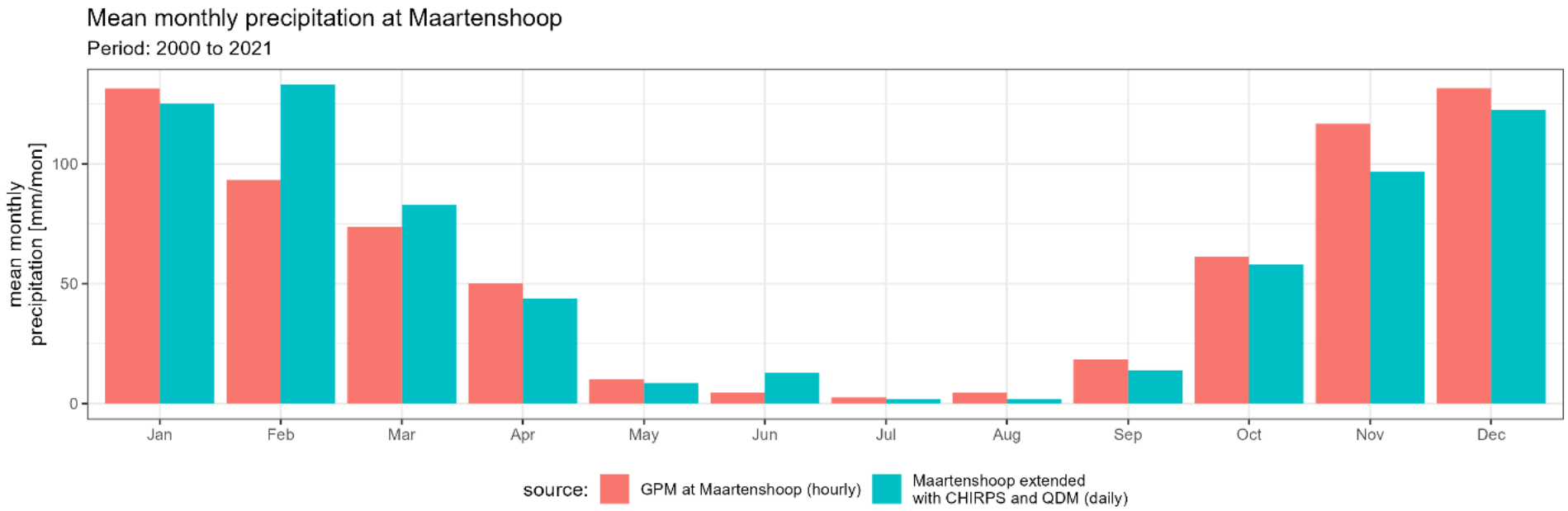
Historical Precipitation

- Quantile Delta Mapping (QDM) was applied to bias correct CHIRPS to extend Maartenshoop data.
- CHIRPS / GPM showed similar elevation gradients with SAWS, with GPM being more regionally representative; however, it does not match Maartenshoop record extension.



Historical Precipitation

- Both extended Maartenshoop and 30-min GPM data showed an average annual rainfall of ~700 mm/year from 2000-2021, confirming their regional accuracy.
- Daily: Maartenshop extended with CHIRPS with QDM
- Hourly: GPM at Maartenshoop



Stochastic Precipitation

Stochastic model:
Bartlett-Lewis Poisson Process
(Hyetos Minute)

- The Bartlett-Lewis rectangular pulse model detailed by Rodriguez-Iturbe et al. (1987).
- Implementation by R library HyetosMinute (Mazi et al, 2020).

Storms time series:

- 1 hr.
- 6 hrs.
- 12 hrs .
- 24 hrs.

⟺

- mean,
- variance,
- Covariance; and,
- dry period probability

⟹ Optimization ⟹

Parameters:
λ, α, ν, κ, ϕ, ω, and μX

Stochastic Precipitation - Historical

Stochastic model:
Bartlett-Lewis Poisson Process
(Hyetos Minute)

1 hr. => GPM at Maartenshoop
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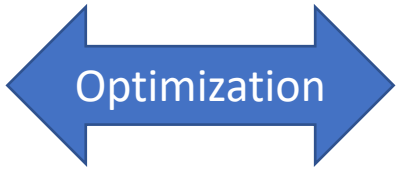

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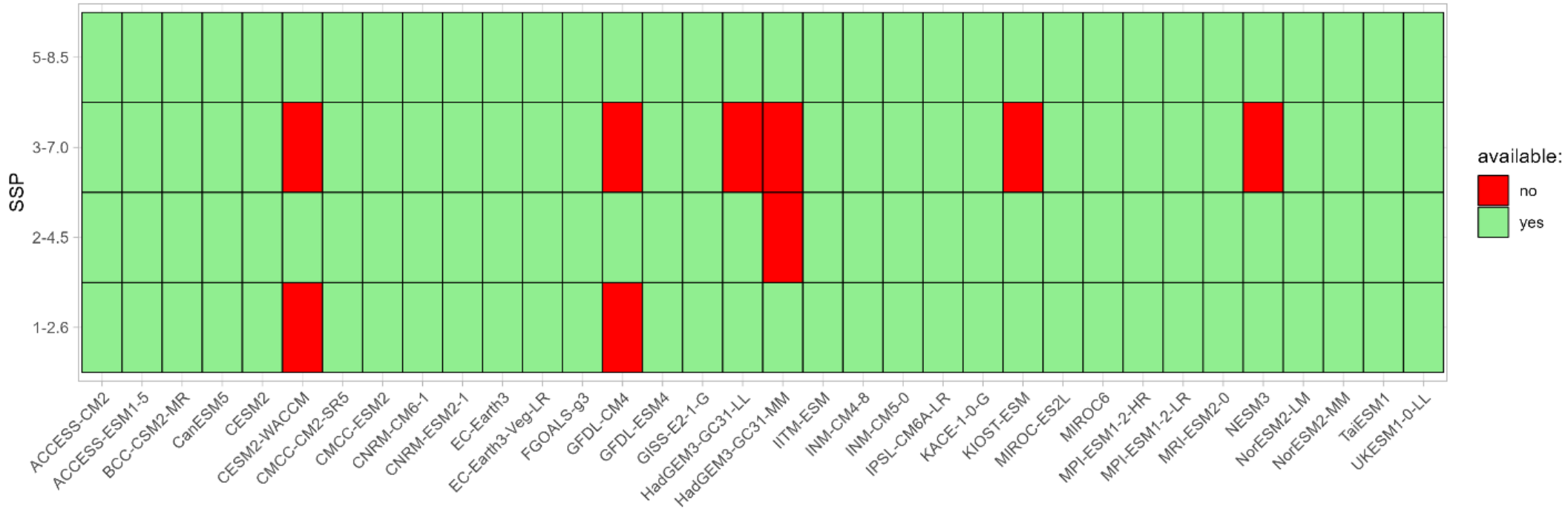
Climate change evaluation

- **Data Source:** NEX-GDDP.
- **Bias Correction:** NEX-GDDP => Bias Corrected Maartenshoop with CHIRPS data (daily)
- **GCM Evaluation:** A total of 127 GCMs for four greenhouse gas emission scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5). Period: 2070 to 2099.



Stochastic Precipitation – Climate Change

Stochastic model:
Bartlett-Lewis Poisson Process
(Hyetos Minute)

1 hr. => GPM at Maartenshoop, GCM scaled[1]
6 hrs. => GPM at Maartenshoop , GCM scaled[1]
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24 hrs=> GCM corrected by Maartenshop extended with CHIRPS with QDM

- mean,
- variance,
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Optimization

Parameters:
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[1] Scaled to align historical GCM with GPM at Maartenshoop

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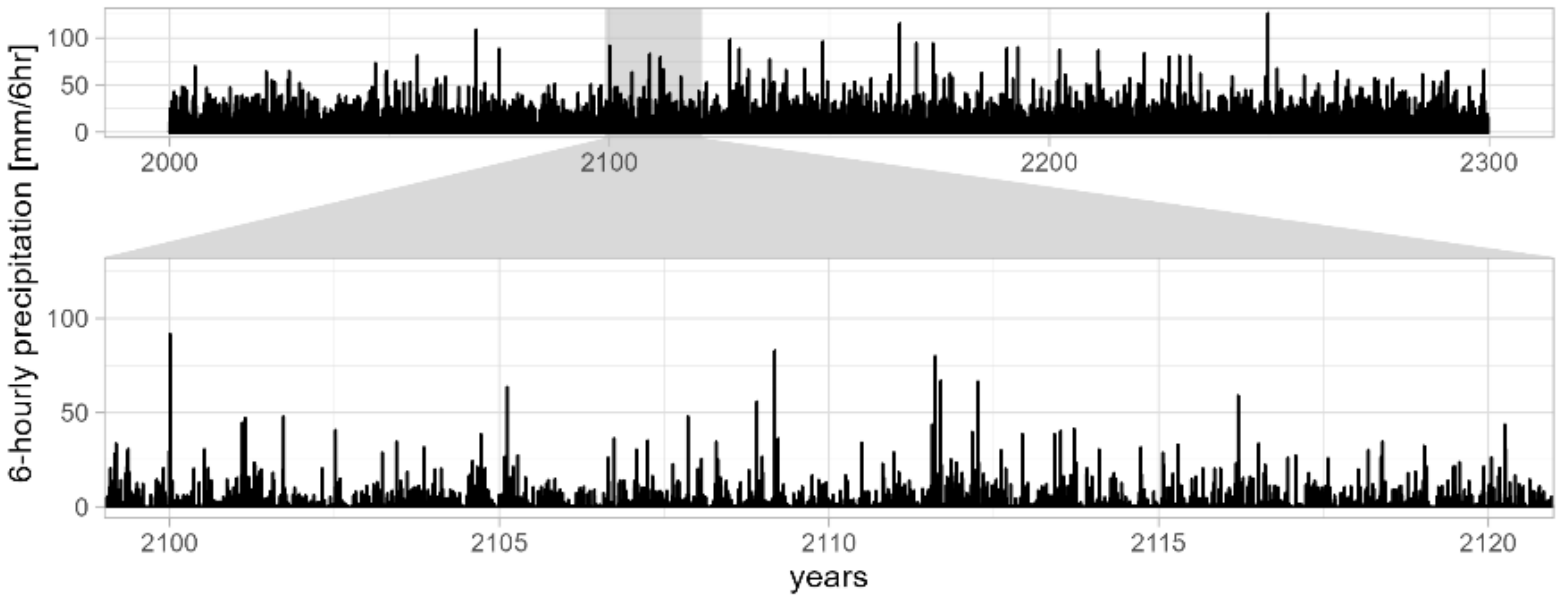
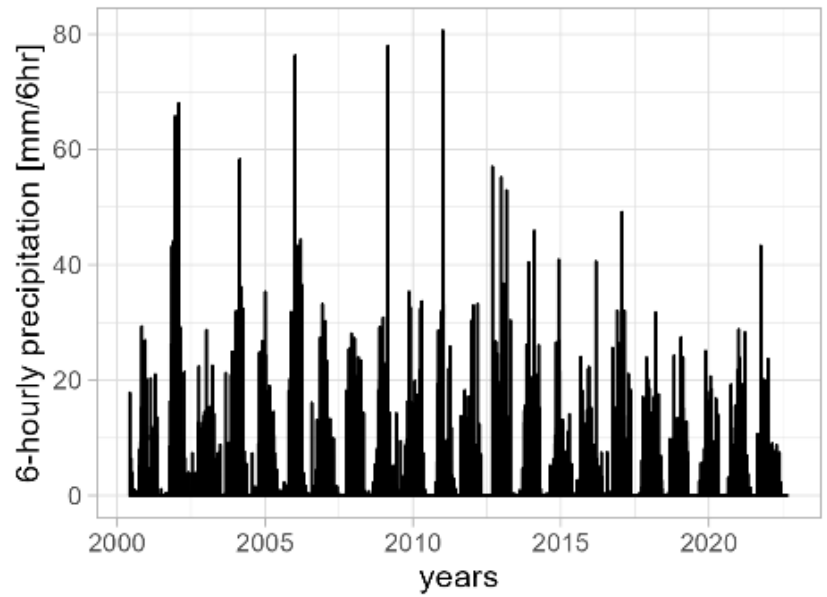
X 127

Stochastic evaluation - Historical

(A)

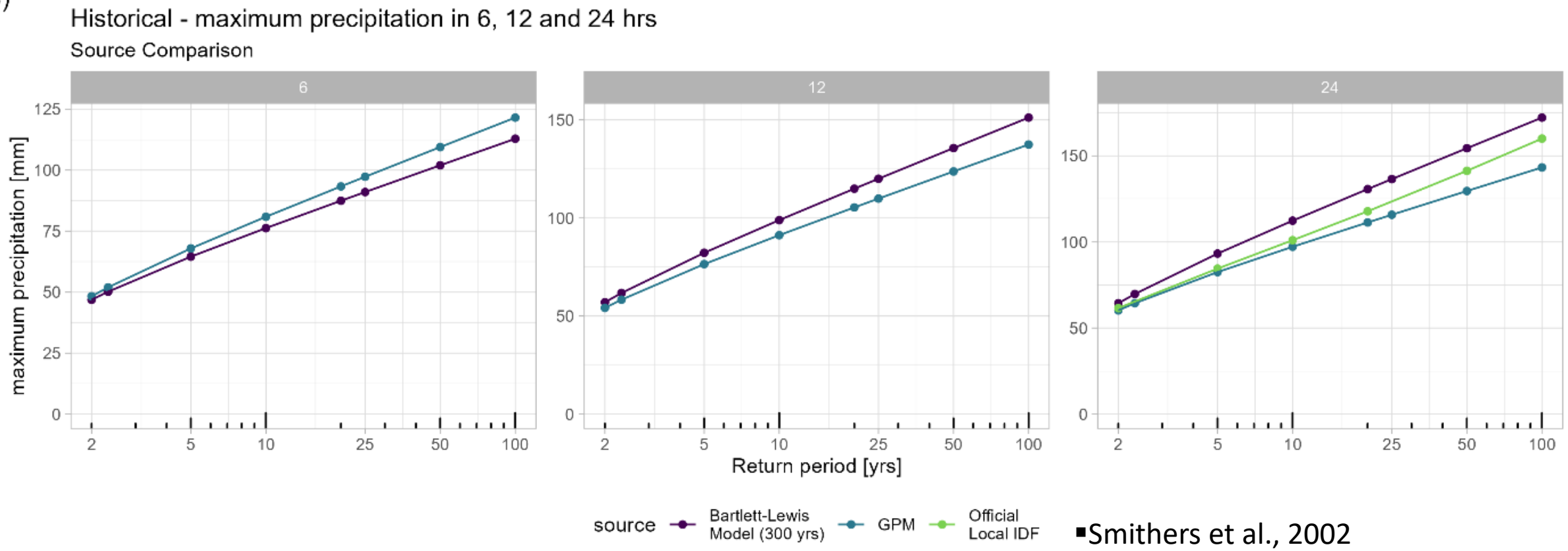


(B)



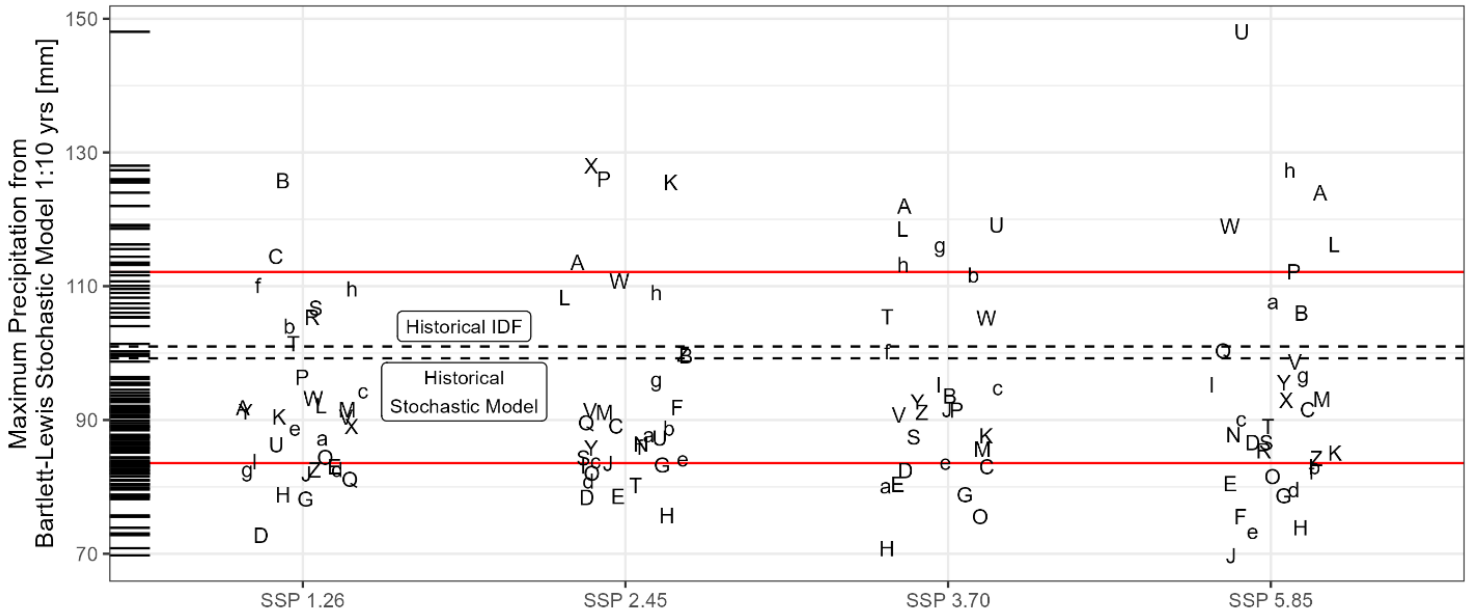
Stochastic evaluation - Historical

(C)



- Smithers et al., 2002

Climate change evaluation - Projection



GCM Model:

A	ACCESS.CM2	H	CMCC.ESM2	O	GFDL.ESM4	V	IPSL.CM6A.LR	c	MRI.ESM2.0
B	ACCESS.ESM1.5	I	CNRM.CM6.1	P	GISS.E2.1.G	W	KACE.1.0.G	d	NESM3
C	BCC.CSM2.MR	J	CNRM.ESM2.1	Q	HadGEM3.GC31.LL	X	KIOST.ESM	e	NorESM2.LM
D	CanESM5	K	EC.Earth3	R	HadGEM3.GC31.MM	Y	MIROC.ES2L	f	NorESM2.MM
E	CESM2	L	EC.Earth3.Veg.LR	S	IITM.ESM	Z	MIROC6	g	TaiESM1
F	CESM2.WACCM	M	FGOALS.g3	T	INM.CM4.8	a	MPI.ESM1.2.HR	h	UKESM1.0.LL
G	CMCC.CM2.SR5	N	GFDL.CM4	U	INM.CM5.0	b	MPI.ESM1.2.LR		

notes: arbitrarily red lines selected as a site references for GCM models

Time series selected as representative for the GCM variability

Summary

- Landform design => hourly precipitation data ranging 100 to 1000 years. However, the output do not align with the Global Climate Model (GCM) results.
- This approach aims to encapsulate GCM variability, but questions remain about the Bartlett-Lewis pulse's capability to accurately mirror this variability.
- The presented methodology is not a definitive solution for GCM integration. Instead, it's an attempt (trade-off) to infuse GCM into the hourly results.

Thanks for your attention in this almost last presentation!

Well done yourself!

Any question?

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