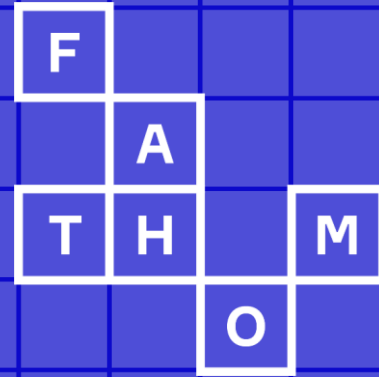


Jorge Sebastián Moraga, Nans Addor,
Natalie Lord, and Chris Lucas
Fathom, Bristol, United Kingdom
s.moraga@fathom.global



Benchmarking against the WRF Dynamical Climate Model

Downscaling Precipitation Projections using GenAI



Introduction

- Climate models (GCMs/ESMs): Great for global projections: Coarse. **Not great at precipitation** modelling.
- Dynamical-model downscaling (**RCMs**): **The best we have.**
- Statistical downscaling: Widely adopted and much **cheaper alternative.**
- GenAI models show great results. We introduce **Downfusion.**
 1. Emulator of an RCM: Trained using coarse climate models and dynamically-downscaled data.
 2. “Traditional” approach: Training using observations, typically fine- and coarsened-reanalysis data.



Methods

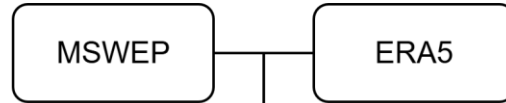
Coarsened (100km) ERA5 climate variables.

10km-scale MSWEP reanalysis **Daily** target.

Downscaling **five CESM2 members** (RCP8.5) using:

1. Our GenAI-based, **Downfusion** model
2. The Dynamical regional climate model **WRF**
 - Historical (1985–2014)
 - Future (2080–2099)

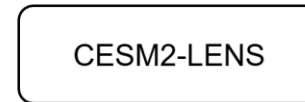
Reanalysis data



Downscaling Models



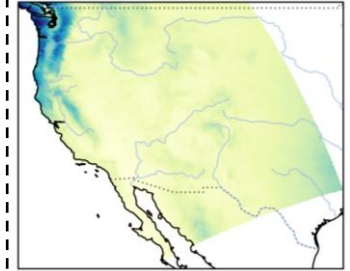
Climate Model Projections



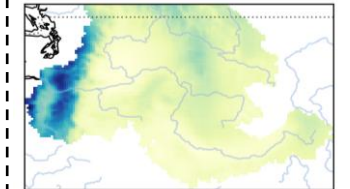
Simulations



Domain Western US

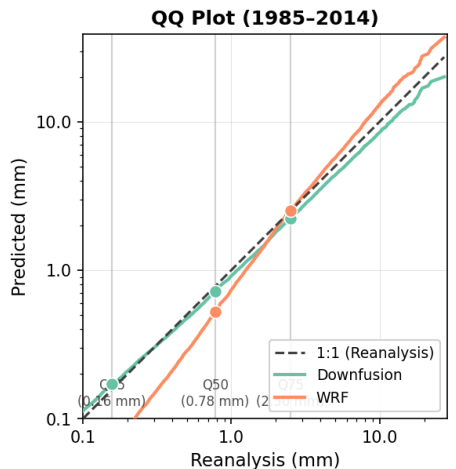


Focus on: Columbia RB

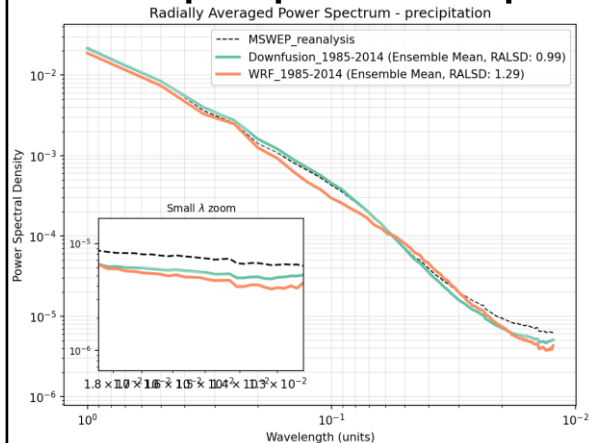


Evaluation

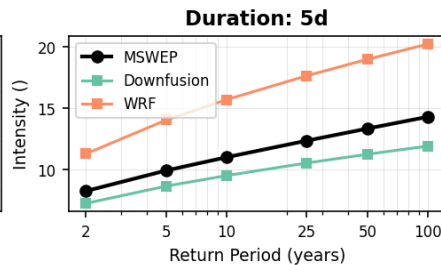
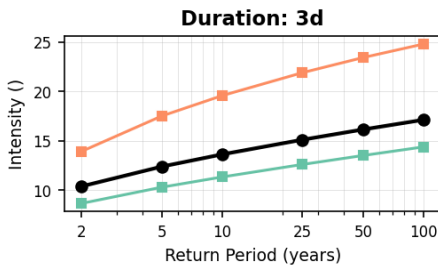
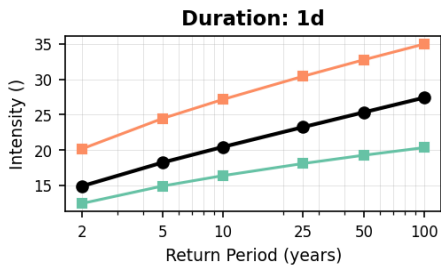
Downfusion does a better at **low precipitation values**
Downfusion underestimates **high percentiles**; WRF overestimates them



Realistic precipitation field patterns



Both models are off when it comes to **extremes**



Evaluation

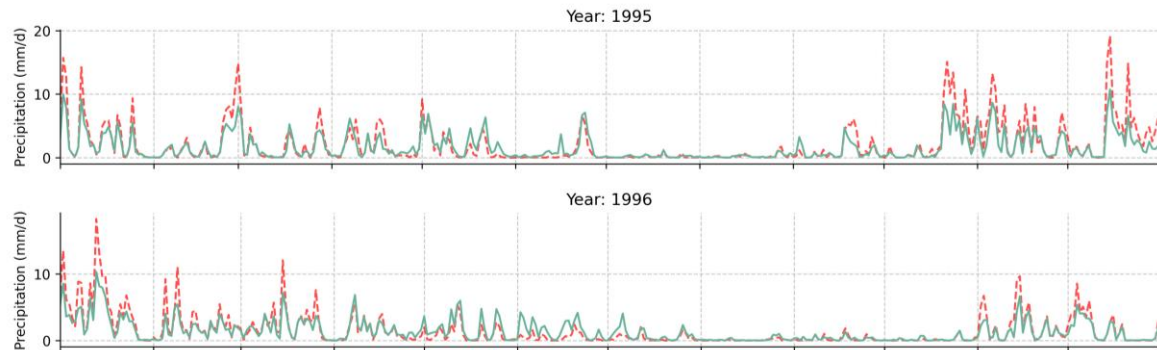
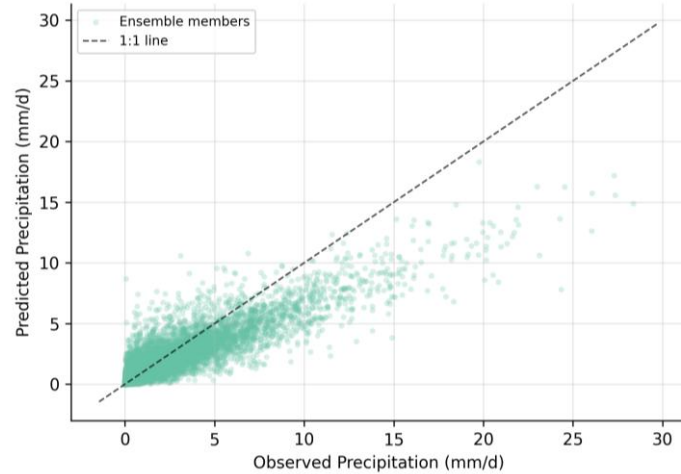
Different biases for historical simulations

High correlation between Downfusion and WRF ($r = 0.90$)

High correlation persists for future simulations! ($r = 0.87$, not shown)

Higher median bias, lower dispersion

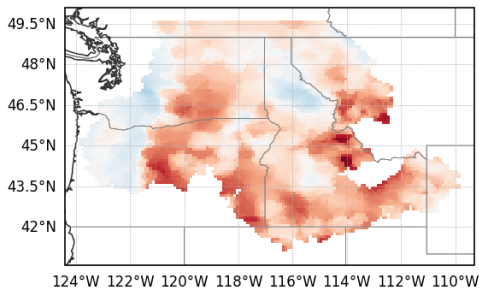
Bias	Downf.	WRF
Median	-12%	1,1%
Std	8.5%	32%



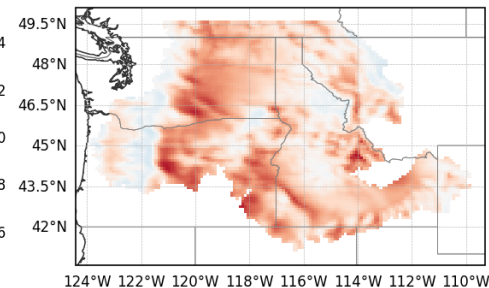
Predicted impacts (Change Factors)

**Spatial Mean Precipitation Change Factors
(2080-2099 / 1985-2014)**

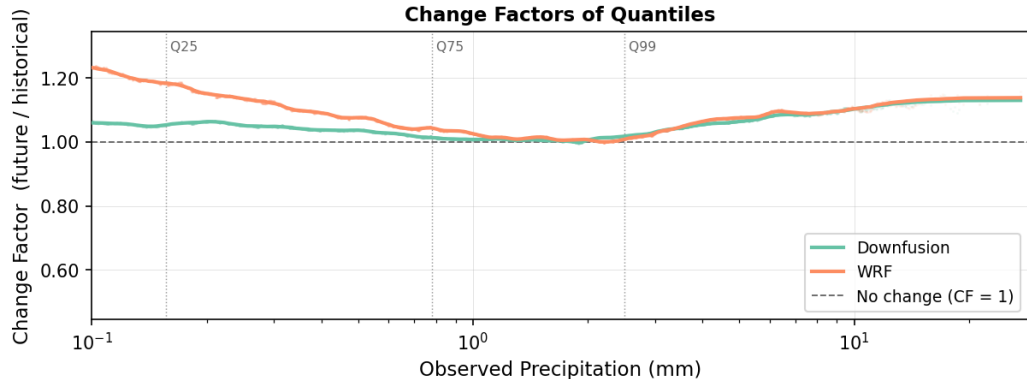
Downfusion



WRF

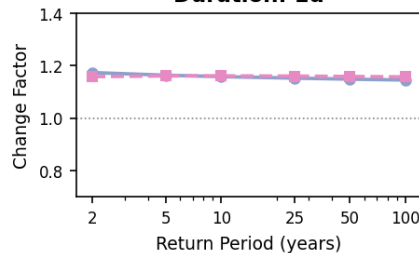


Change Factors of Quantiles

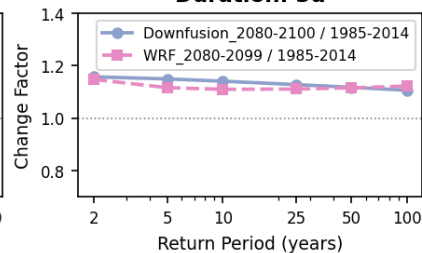


IDF Change Factors (2080-2100 / 1985-2014)

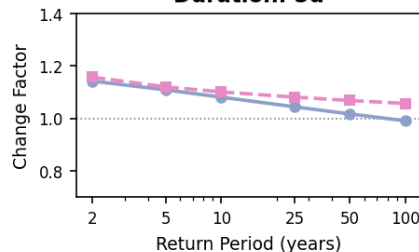
Duration: 1d



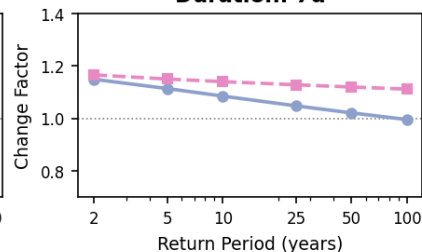
Duration: 3d



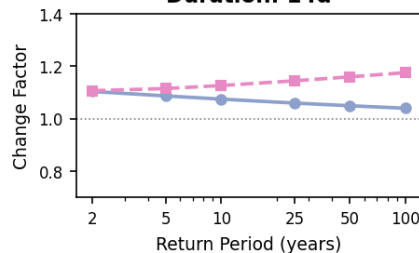
Duration: 5d



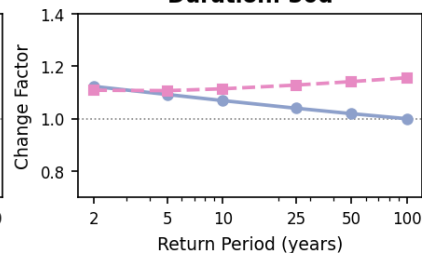
Duration: 7d



Duration: 14d



Duration: 30d



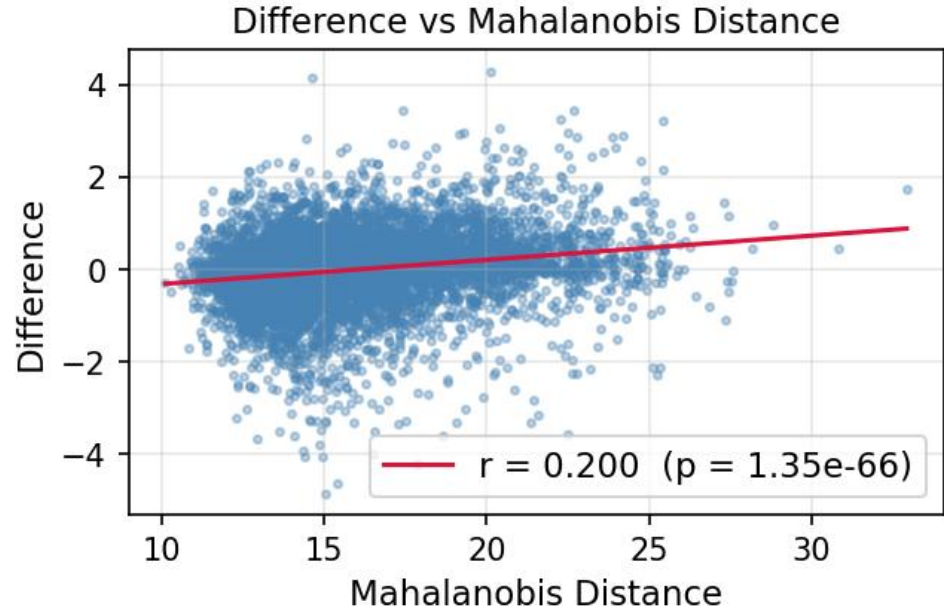
Climate-driven discrepancies

Do the differences between Downfusion and WRF correlate with “rareness” of predictors?

Quick and dirty analysis:
PCA to assess “rareness” of
the day’s climate state

Low correlation ($r = 0.20$).
Even lower for high
discrepancies (not shown):

- Diff > 1mm: $r = 0.18$
- Diff < -1mm: $r = -0.12$



Conclusions and Open Questions

- Positive evaluation against reanalysis.
- Benchmarking data-based Downfusion against dynamical WRF
 - High 1:1 correlations between models
 - Downfusion does not capture the low-values change signal
 - Downfusion does great for high precipitation, low durations
- A data-based model that can extrapolate extreme precipitation
- Can we find explanations for discrepancies between models?



Sebastian Moraga
s.moraga@fathom.global

