A comparative study of stochastic and deep generative models for multisite precipitation synthesis

Jorge Guevara, Dario Borges, Campbell Watson, Bianca Zadrozny

IBM Research

ICML 2021 Workshop
Tackling Climate Change with Machine Learning

Introduction

Evaluation of classical stochastic weather generators vs deep generative models

Multisite precipitation synthesis

Provide a set of metrics

Improve the design of end-to-end deep generative models for the task

Challenges

No single evaluation metric

Evaluation depending on the application

- Climate change, downscaling, flood and streamflow modeling

There are not generic and open-source evaluations APIs

Few open-source weather generators available for customization

No previous works are validating ML approaches for this task

CHIRPS Data

Region of Palghar India

0.05 ° spatial resolution

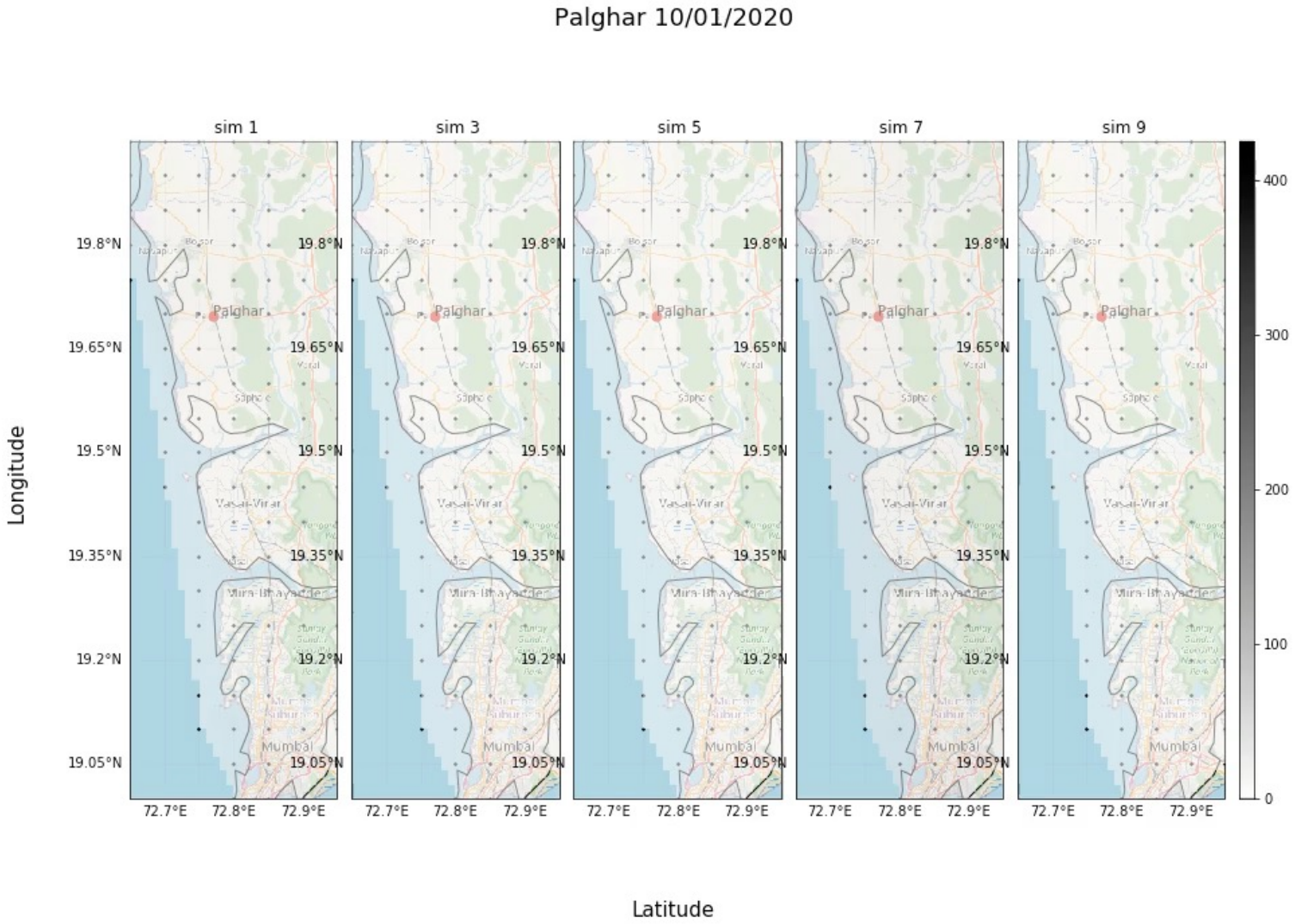
30 years, daily resolution (mm/day)

- 01-01-1981 to 31-12-2009

1° x 1° Bounding box

- (19 ° N, 72 ° E) (20 ° N, 73 ° E)

400 latitude, longitude pairs (sites)



IBM weathergen simulations

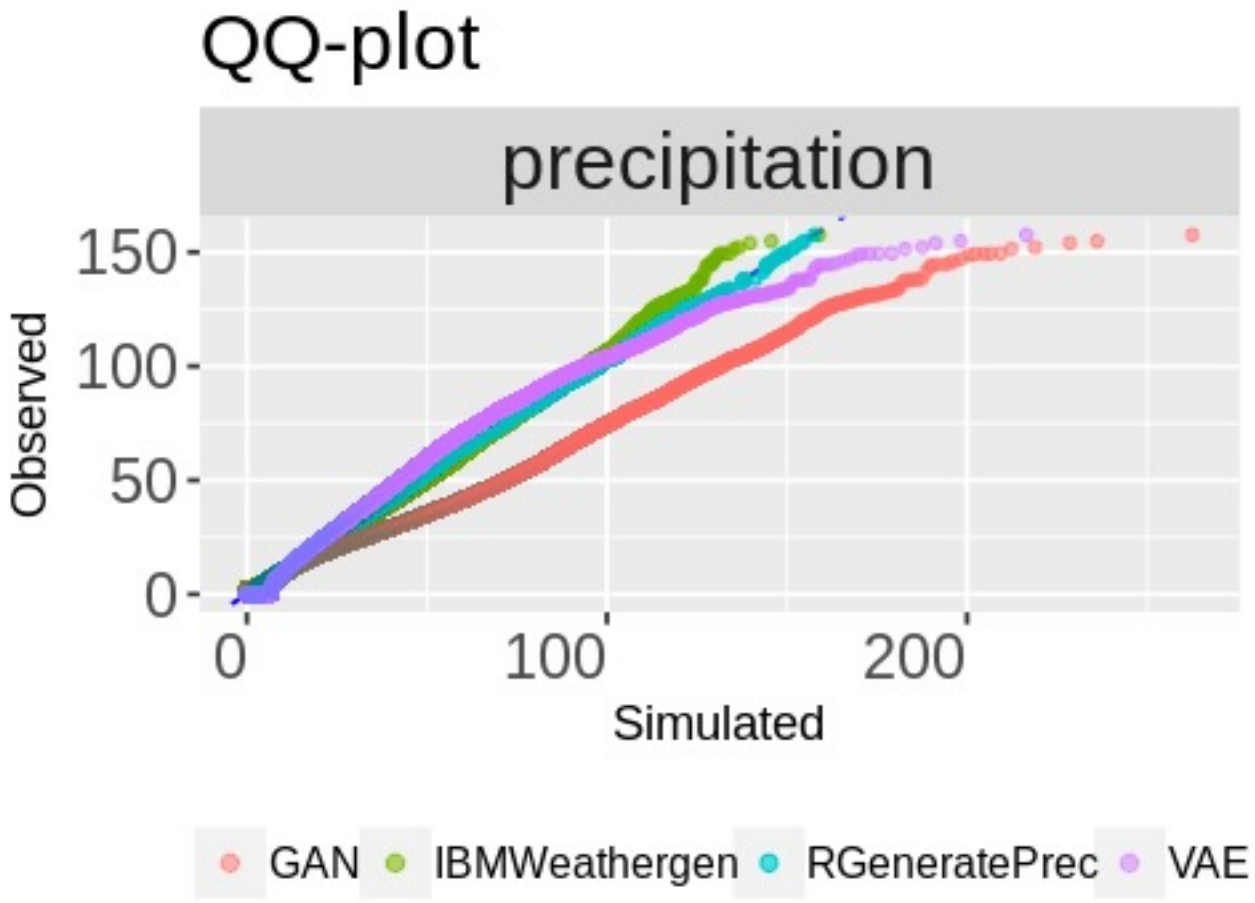
Weather generators

IBM Weathergen :	multisite and multivariate ARIMA, kernel weighted KNN bootstrap sampling, homogeneous Markov chains
RGeneratePrec:	multisite precipitation generator Wilk's approach with mixed exponential distribution heterogeneous Markov chains via GLM
Vanilla VAE:	Encoder: 32x32x32 input, 2conv layers+(RELU), dense layers (RELU) Decoder: dense layer, 256 maps (8x8x8), convolution layers, 32x32x32 output
Vanilla GAN :	Similar classification layer to implement the discrimination loss used to train the generator network

Preliminary results

Global Comparison

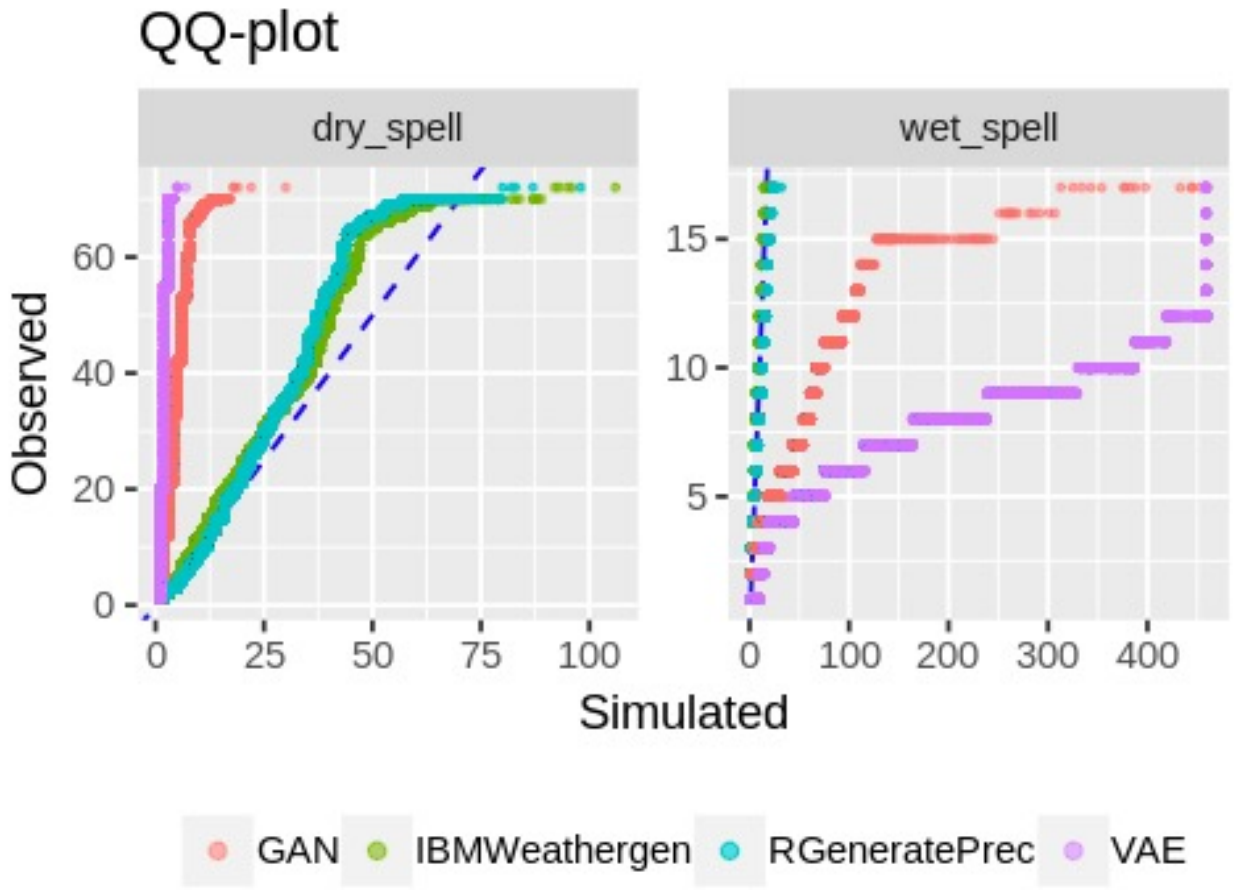
Observed vs simulated
Precipitation values (mm/day)



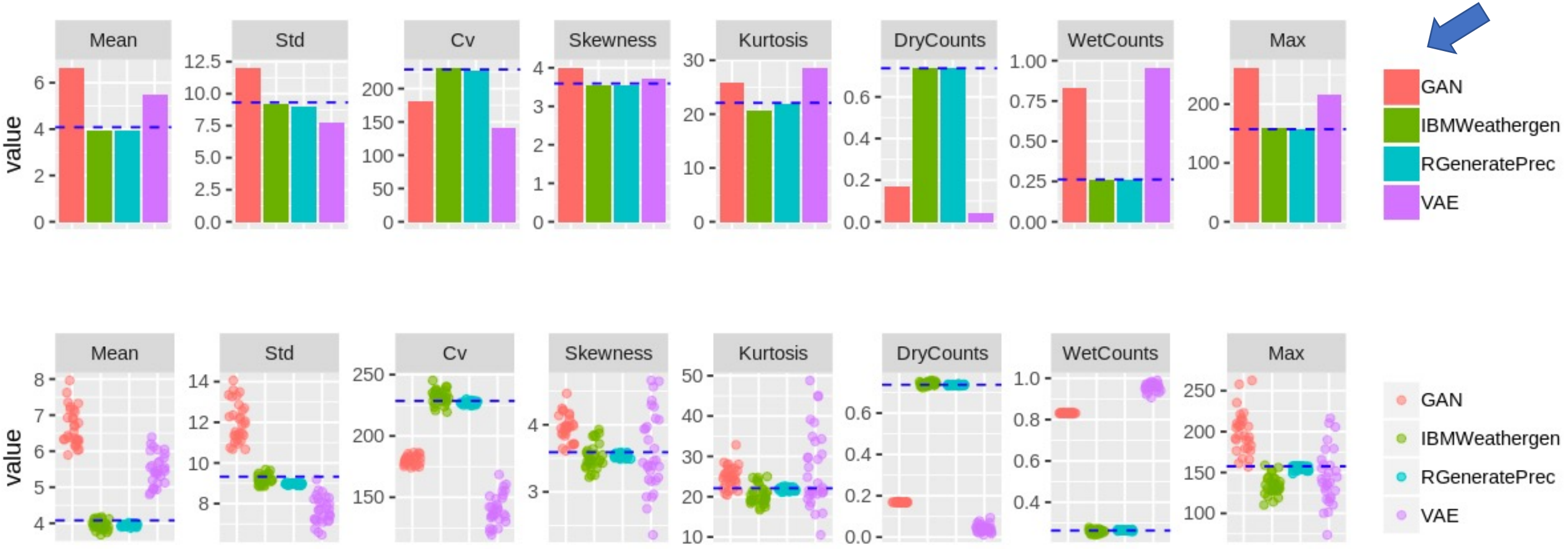
Preliminary results

Global Comparison

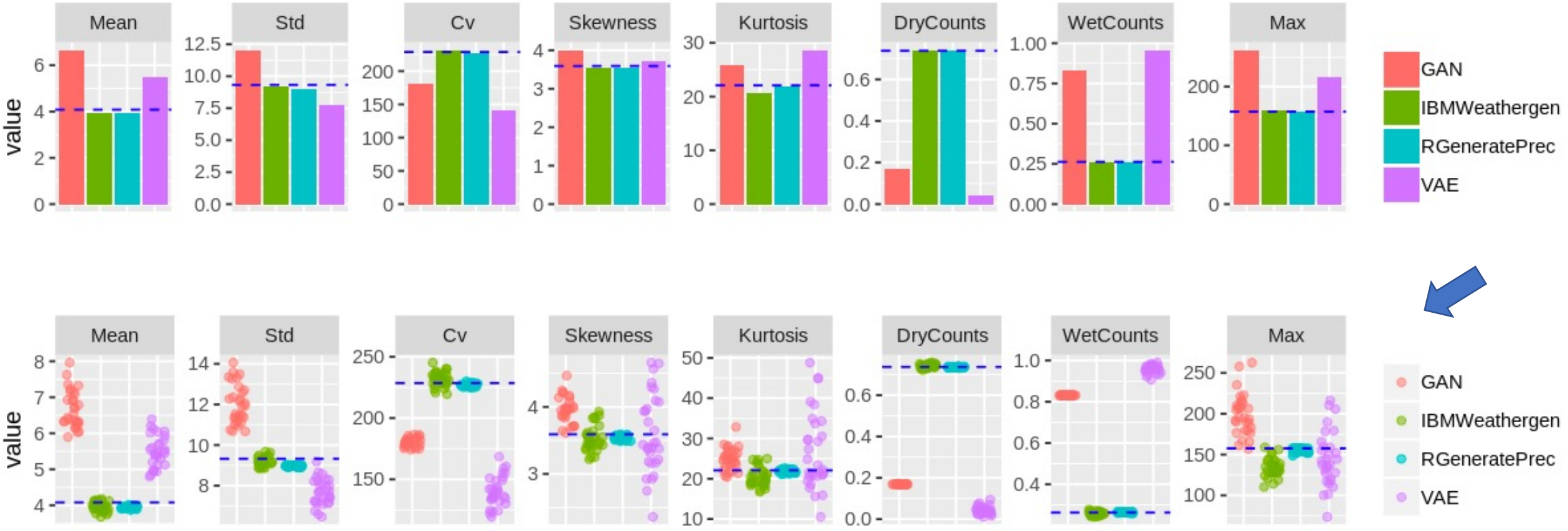
Observed vs simulated
Dry/wet spell lengths



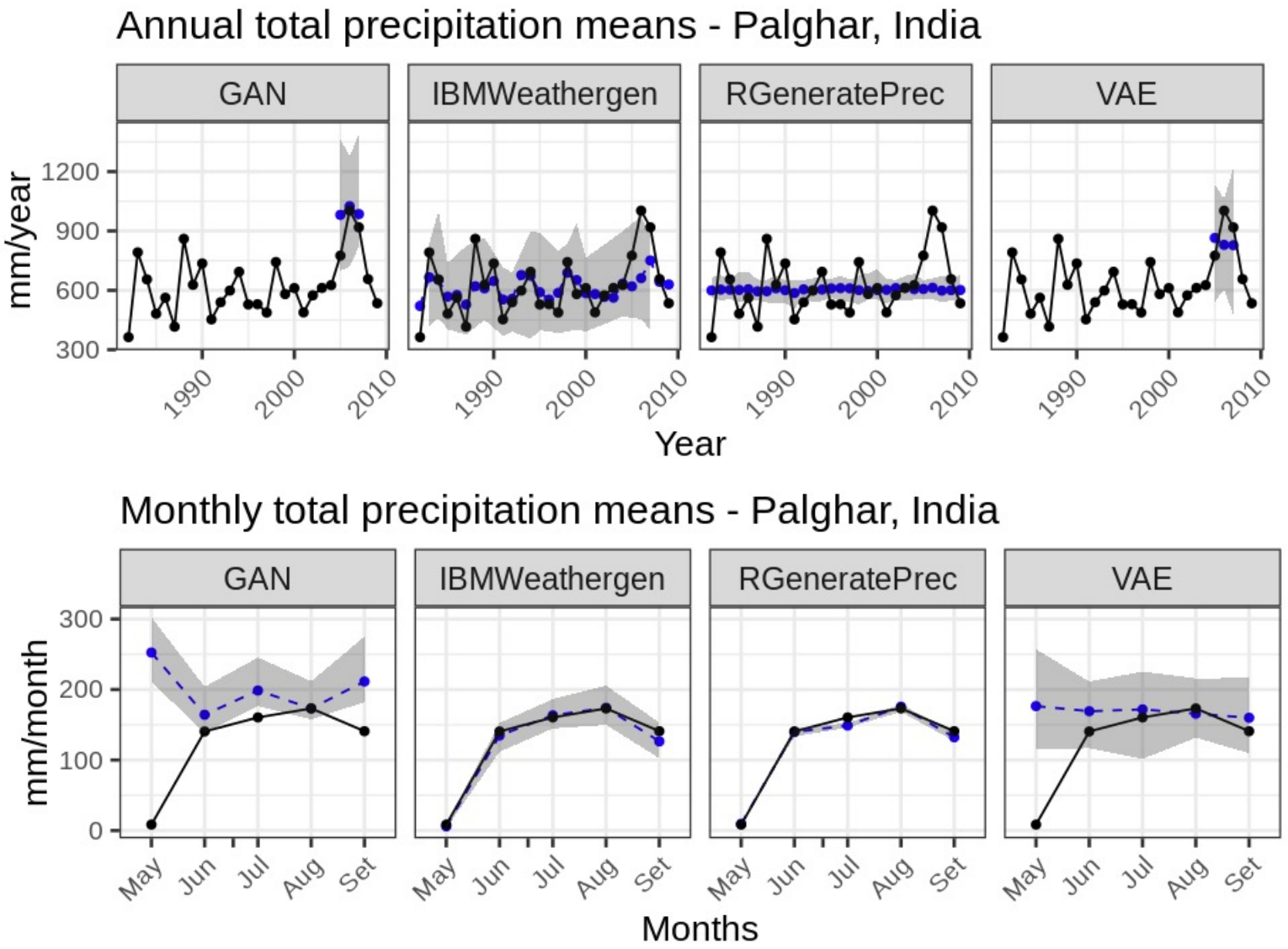
Preliminary results



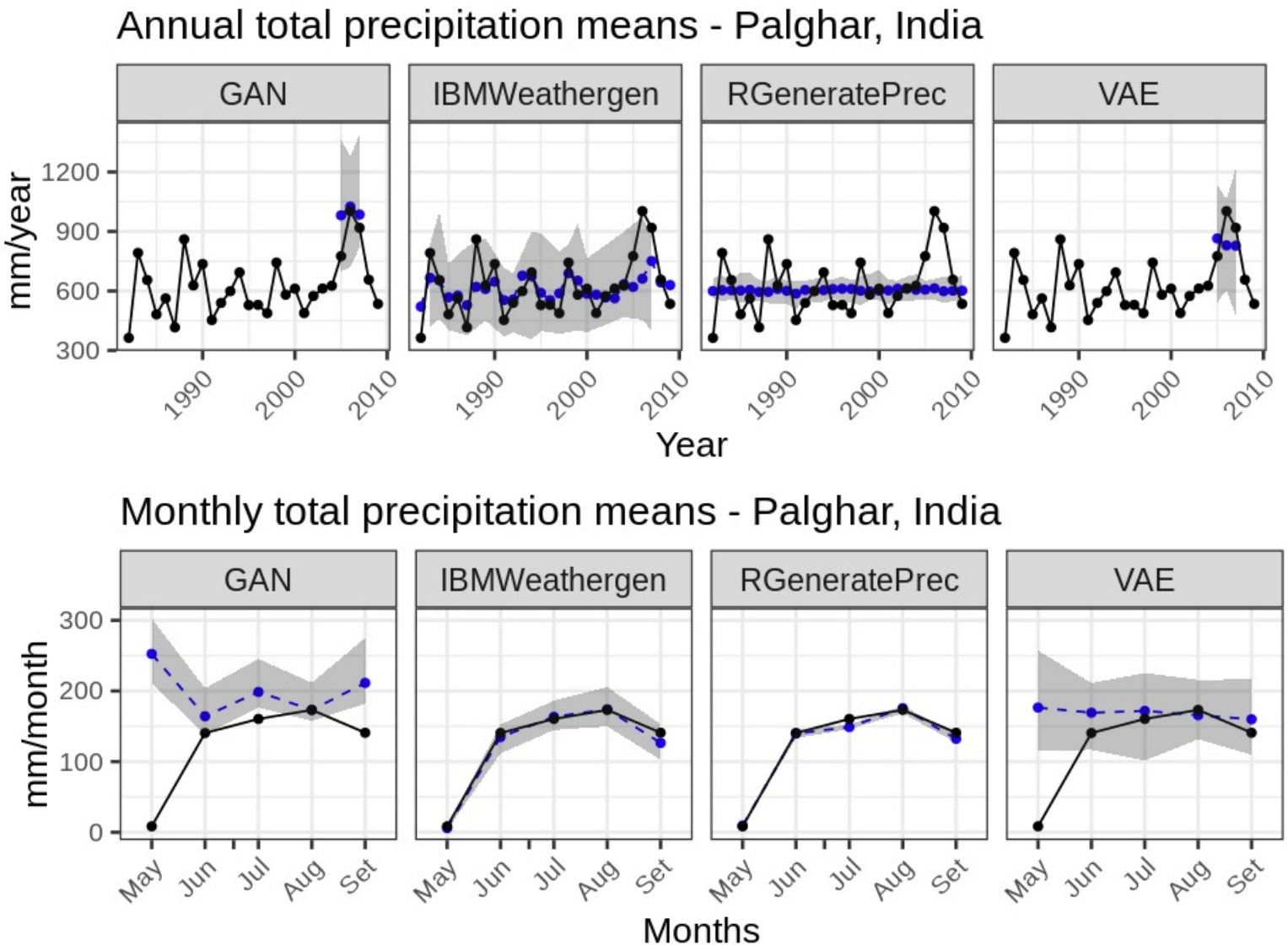
Preliminary results



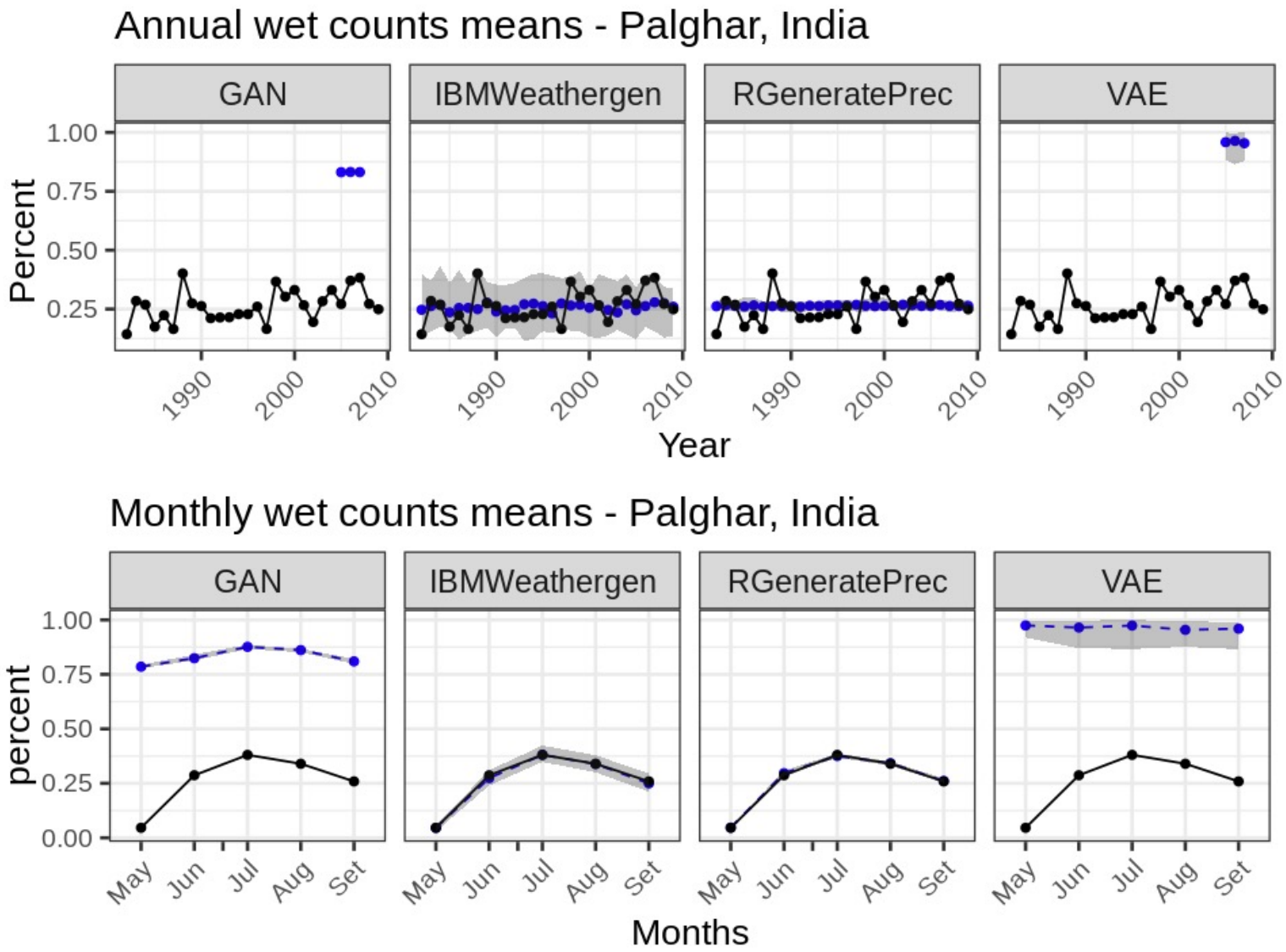
Preliminary results



Preliminary results



Preliminary results



Preliminary conclusions

IBM weathergen was the better

RGeneratePrec: less variability, no model annual variation

GAN & VAE:

- model somehow the overall distribution of precipitation values
- Overestimate/underestimate some quantitative measurements
- Don’t respect dry/wet spell length statistics
- Fail to follow the annual precipitation variability
- Follow closely monthly variability

Future steps

Super resolution metrics

Spatial coherence metrics

How to constrain DL models to follow specific patterns found in data (e.g., dry/wet spell statistics)?

How to couple DL models with temporal modeling concerning the annual and monthly variability?

How to add control capability to deep learning models for generating extreme scenarios (extreme rainfalls, long dry/wet spells, etc.)?

How to condition the models to forecasting values? and so on.