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Correcting biases in climate simulations using unsupervised image-to-image-translation networks

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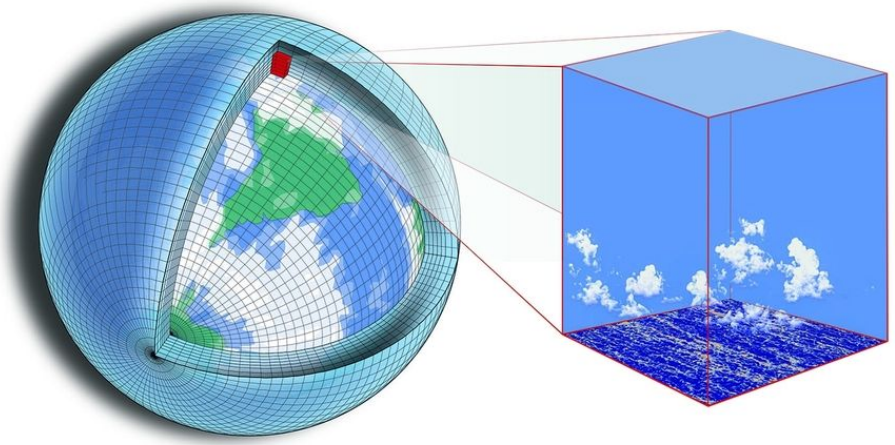
Abstract

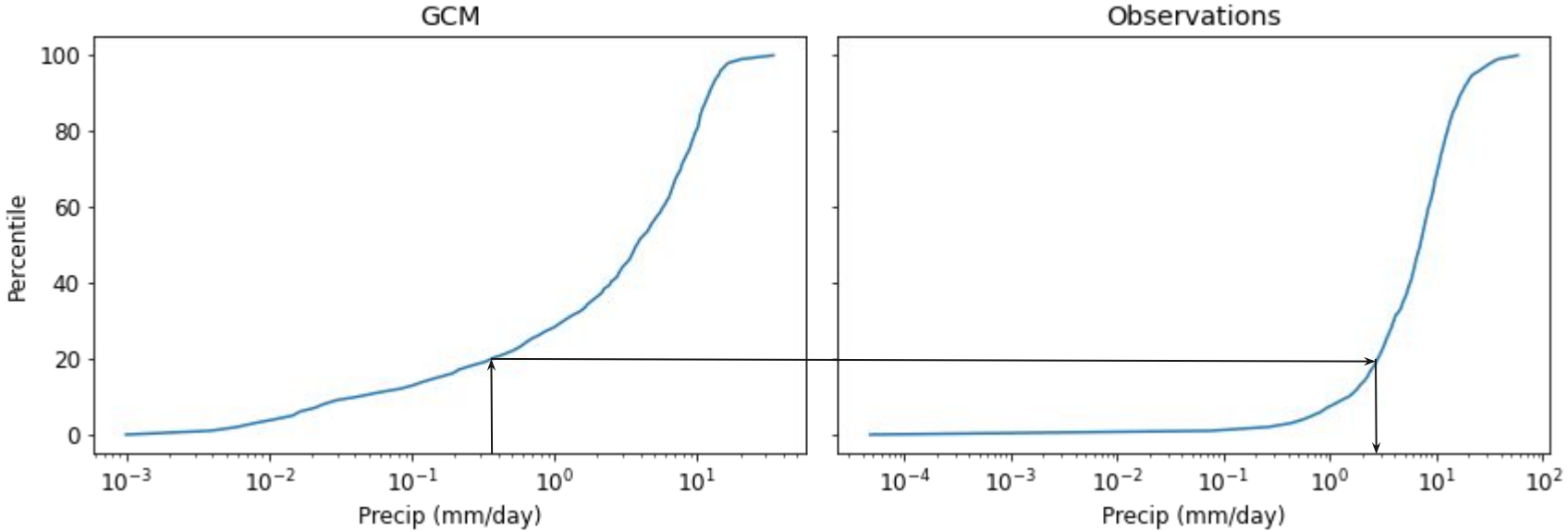
Motivation - imperfect global circulation models

- GCMs aren't perfect representations of the earth system
- Current outputs are important for policy relevant research
- **We need to make best use of the simulation results via post-processing**



https://news.mit.edu/2018/new-climate-modeling-alliance-clima-1212

The status-quo: Quantile mapping



Unsupervised image to image translation

Deep learning networks learn mapping between image domains without supervision

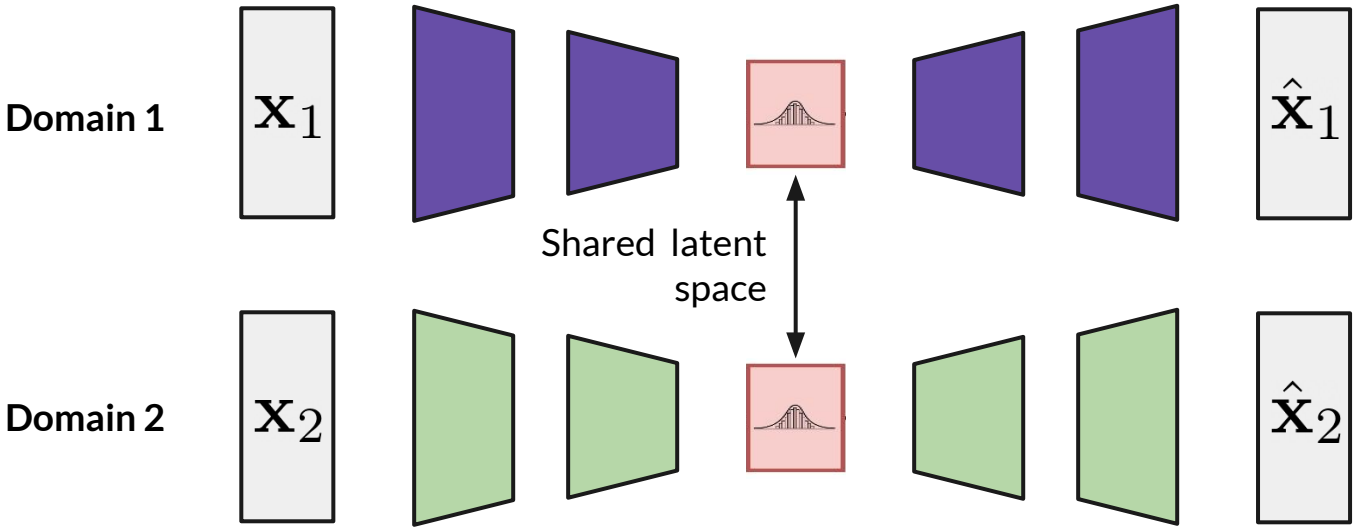
E.g. Deep learning architectures UNIT [1], CycleGAN [2], AlignFlow [3] , etc.

GTA → Cityscapes

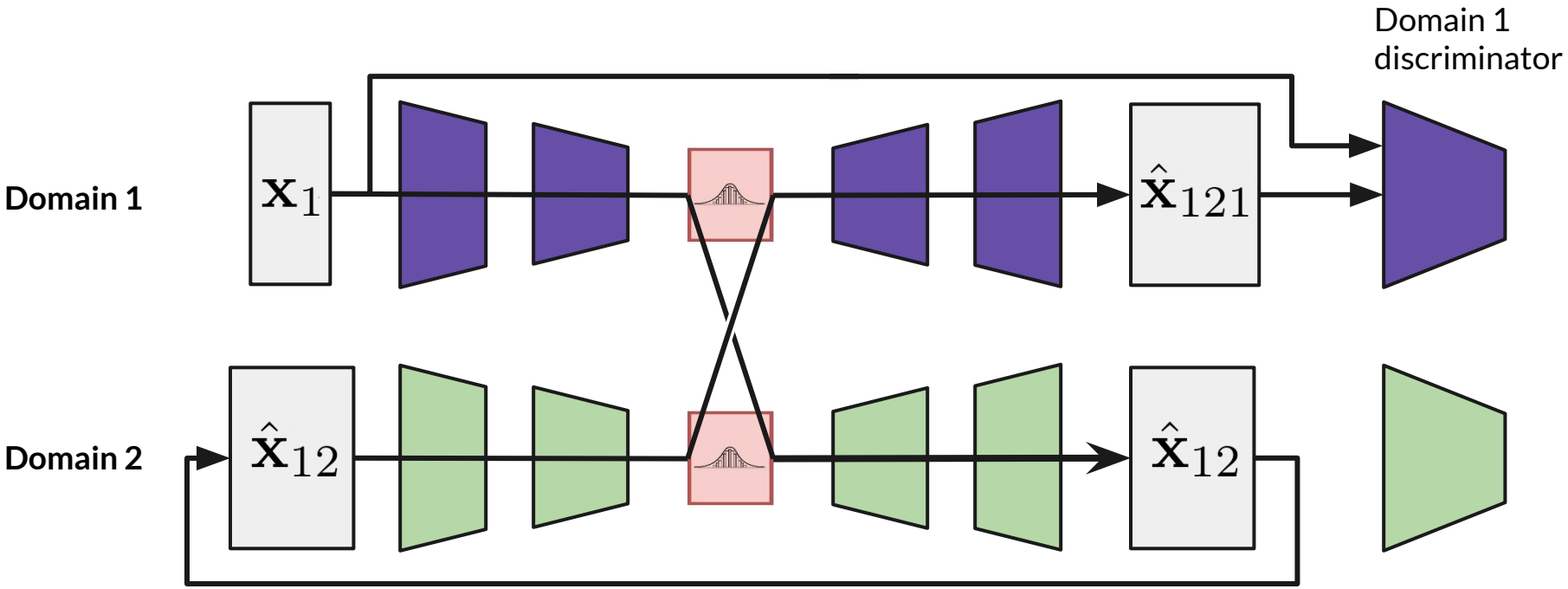
Example image translation from [2]

- **This 'bias correction' is performed without corresponding input-output pairs**
- Long GCM simulations can't be used to create corresponding pairs to the observations

UNIT [1] - UNsupervised Image to image Translation network

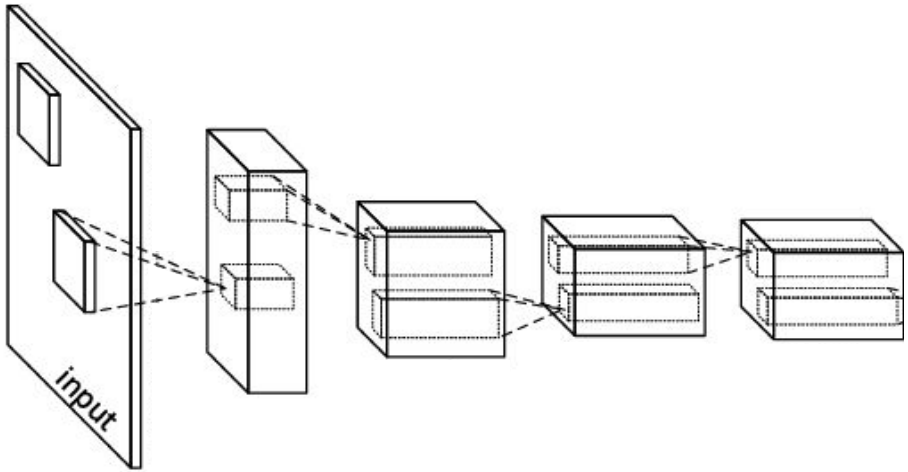


UNIT [1] - UNsupervised Image to image Translation network



UNIT advantages

- Convolutional layers means translation simultaneously across all variables and large scales
- `Sees' cross-variable relations
- `Sees' spatial relations
- Helpful for compound extreme events



Data sources and extent

Physical variables

- Daily min, mean, and max temperature
- Daily total precipitation
- Z500 geopotential height

Data sources

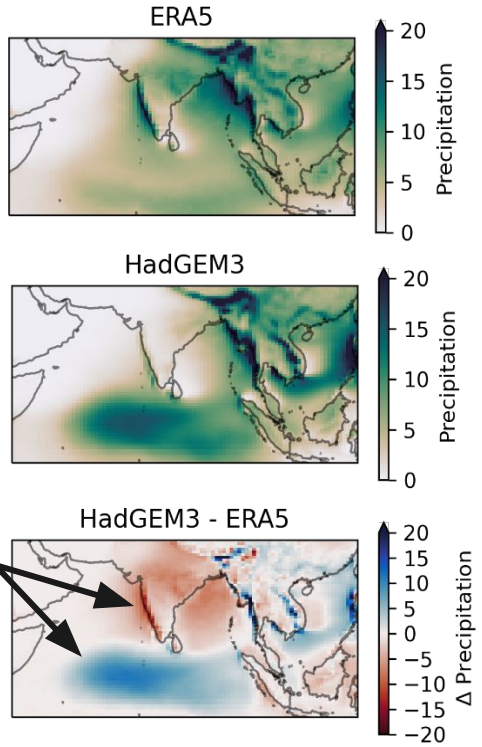
- HadGEM3
  - C20C+ archive
  - Historical recreation scenario
- ERA5

Spatial extent

- South Asian monsoon region
  - 8°S - 30°N, 44°E - 121°E
- Has large **known biases in precipitation**

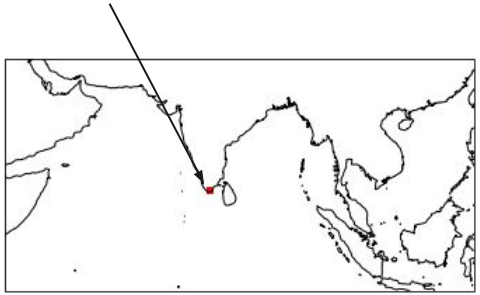
Time period

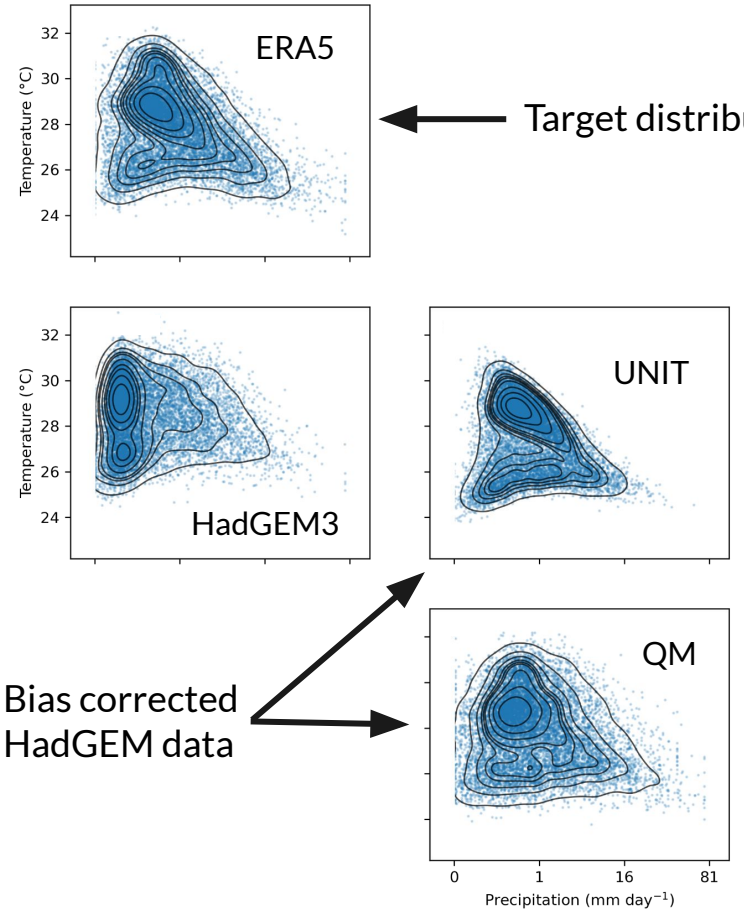
- Jan 1979 - Dec 2013
- Approx. 12 000 days



Cross-variable biases

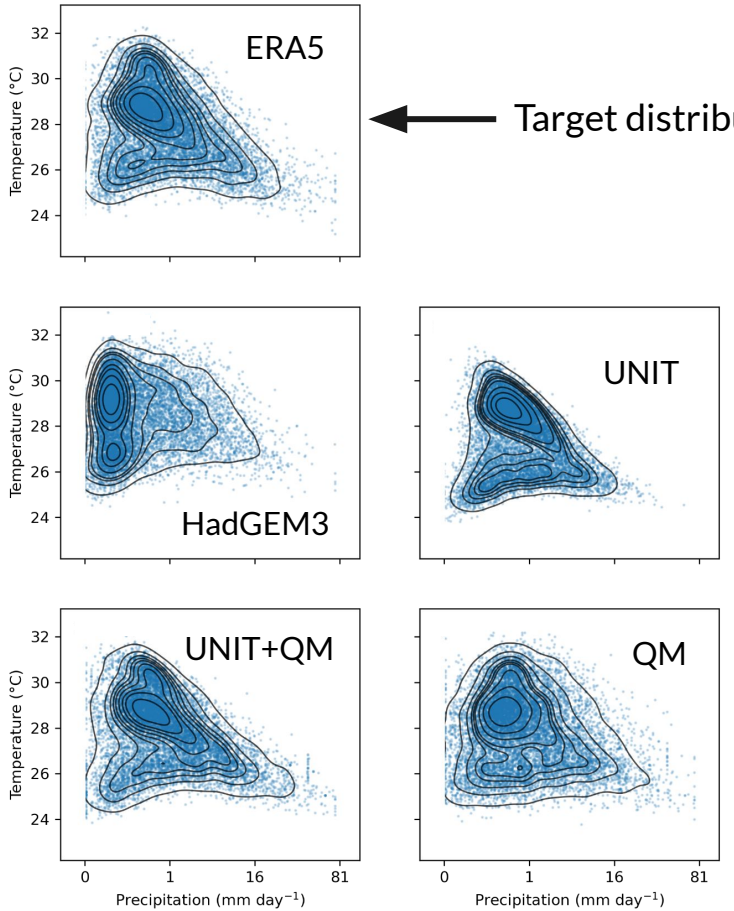
- Joint distribution sampled from <u>single spatial location</u>





UNIT+QM

- Apply UNIT transform
- Then apply quantile mapping



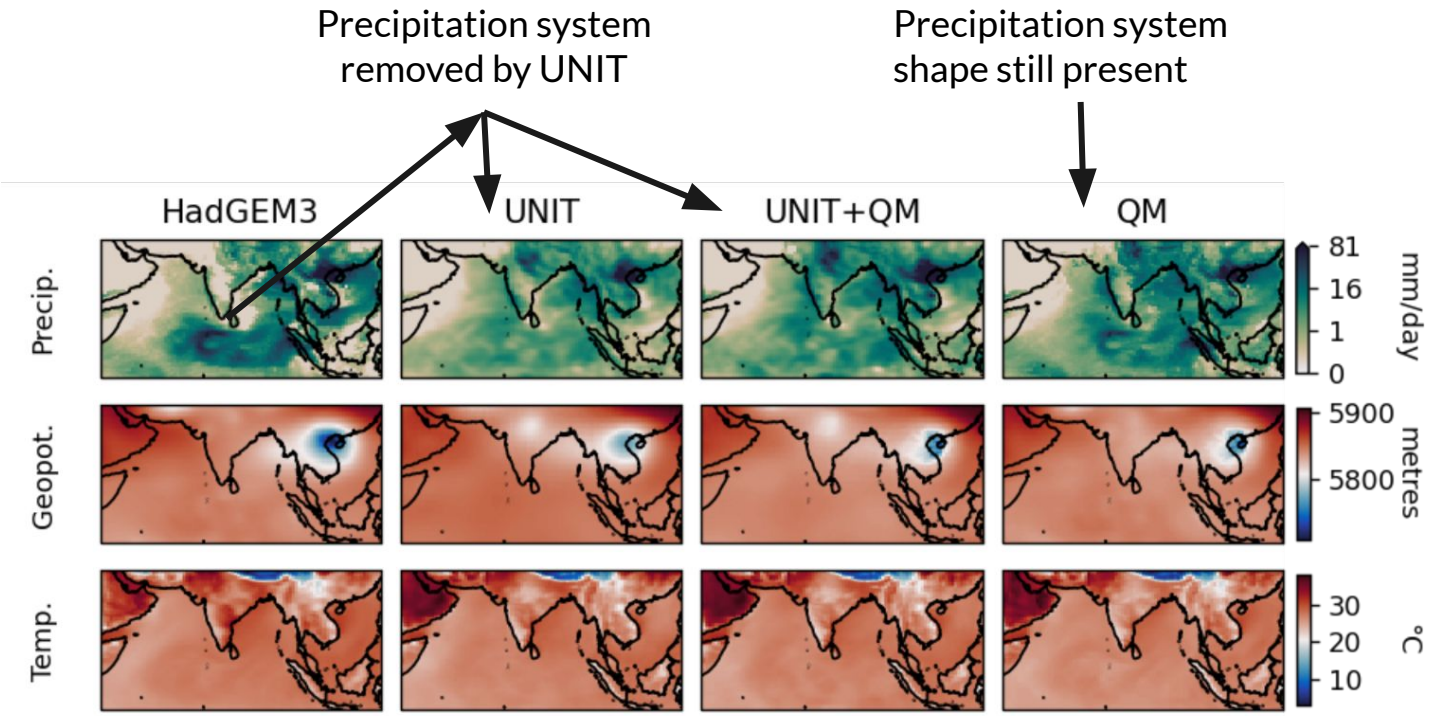
More results

UNIT+QM:

- Maps 1D distributions like QM
- Maps cross-variable distributions better than QM
- Maps spatial correlations better than QM

Submitted article:

***Bias correcting climate model simulations using unpaired image-to-image translation networks* submitted**
Artificial Intelligence for the Earth Systems (*AIES*) - American Meteorological Society


Precipitation system
removed by UNIT
Precipitation system
shape still present
HadGEM3
UNIT
UNIT+QM
QM
Precip.
Geopot.
Temp.
81
16
1
0
mm/day
5900
5800
metres
30
20
10
°C

References

1. Liu, M.Y., Breuel, T. and Kautz, J., 2017. *Unsupervised image-to-image translation networks.*
2. Zhu, J.Y., Park, T., Isola, P. and Efros, A.A., 2017. *Unpaired image-to-image translation using cycle-consistent adversarial networks.*
3. Grover, A., Chute, C., Shu, R., Cao, Z. and Ermon, S., 2020, April. *Alignflow: Cycle consistent learning from multiple domains via normalizing flows.*

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