A plethora of conceptual models is available: What are the dynamic differences?

We investigate how climate forcing influences the streamflow simulation potential of different lumped conceptual models

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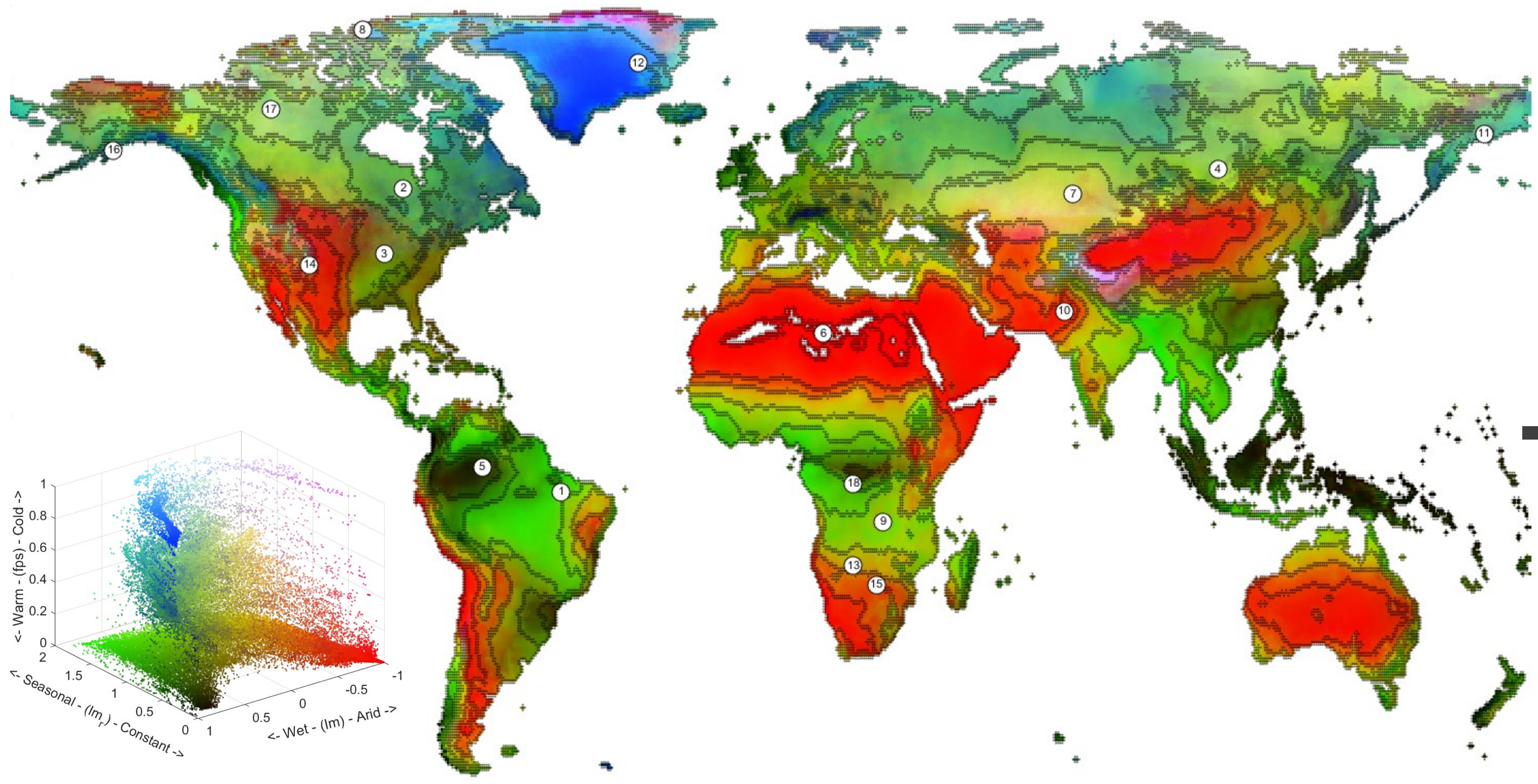
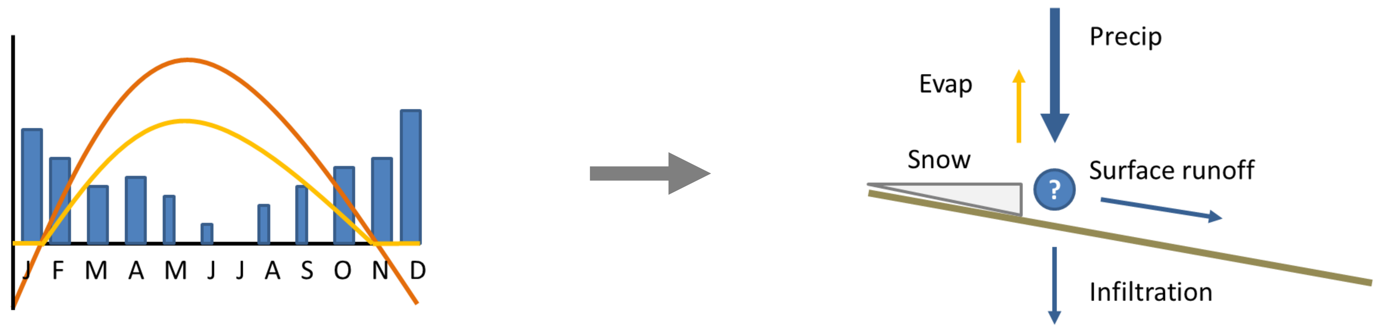
We find 18 representative climate classes...

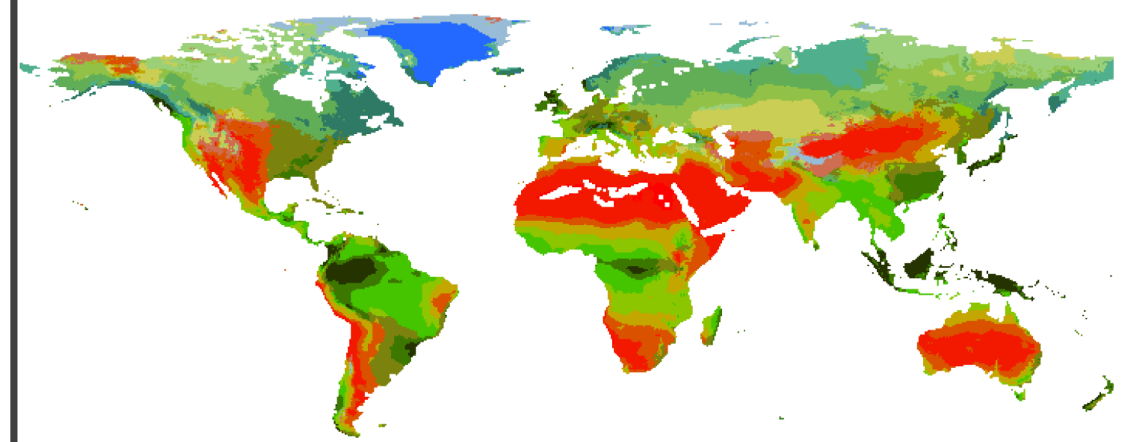


Selected locations are centroids from k-means clustering analysis of climate indices. Indices describe aridity (Im), aridity seasonality (Im_R) and fraction P as snow (fps).

Climate is an important control on the water balance and on water movement/partitioning - or lack thereof



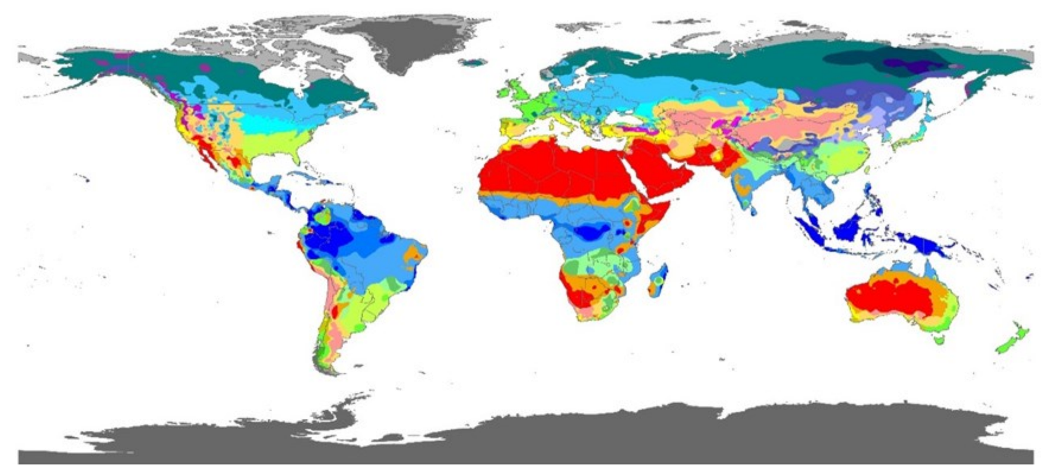
Rain, temperature and potential evapotranspiration interact to control (1) aridity, (2) snowfall, (3) rainfall intensity. (1) and (2) are largely non-correlated on a global scale and are used to cluster the global climates in representative groups.



K-means clustering based on aridity and snowfall

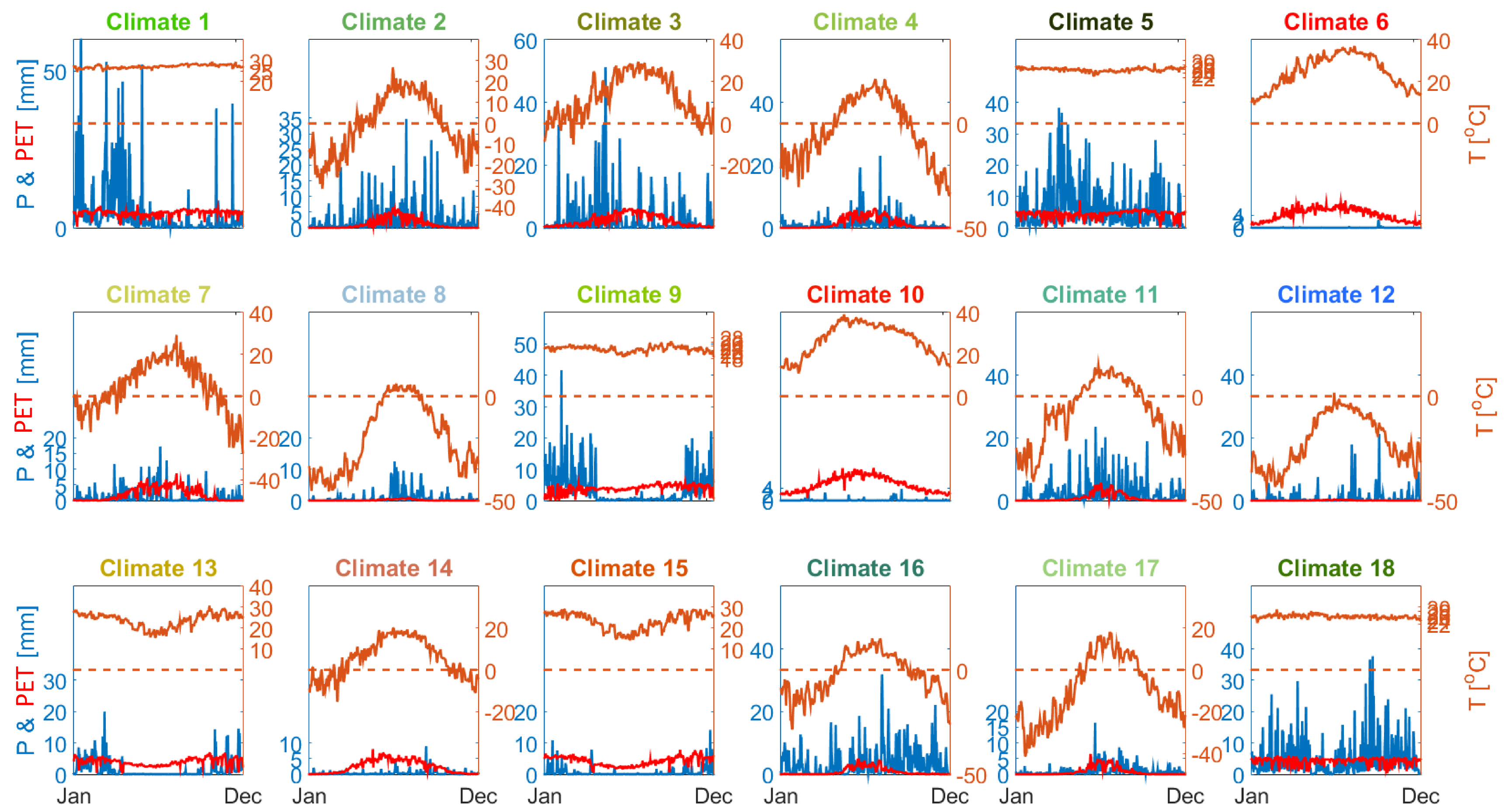
Annual average aridity, aridity seasonality & fraction P as snow control the clustering results (borders as figure at the top, colours are those of centroids).

Köppen-Geiger classification based primarily on temperature

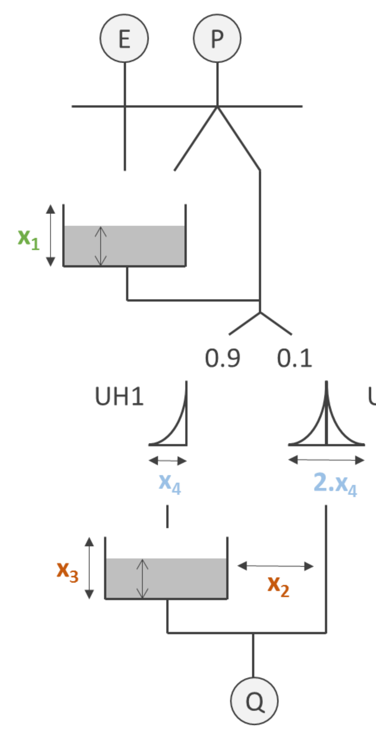


Differences with the Köppen-Geiger classes [1] occur mainly in areas with strong seasonality. What are your thoughts on these differences?

...and use daily data from each as model forcing



The models have different structures and represent a selection of processes (snow, soil moisture, deep store, runoff store, routing). We investigate if, given the same forcing, the models behave differently.

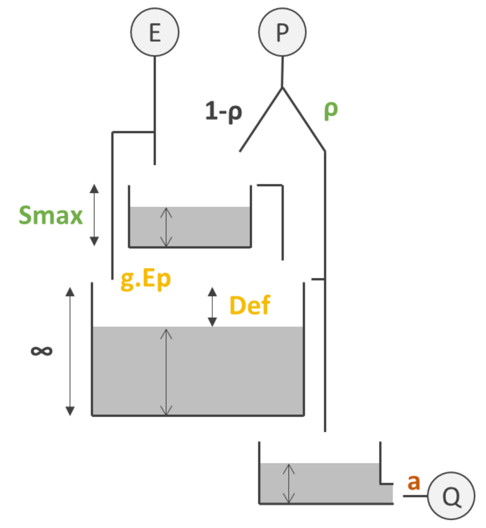


GR4J[2]

x1	[1, 2000]
x2	[-8, 14]
x3	[1, 300]
x4	[0, 5]

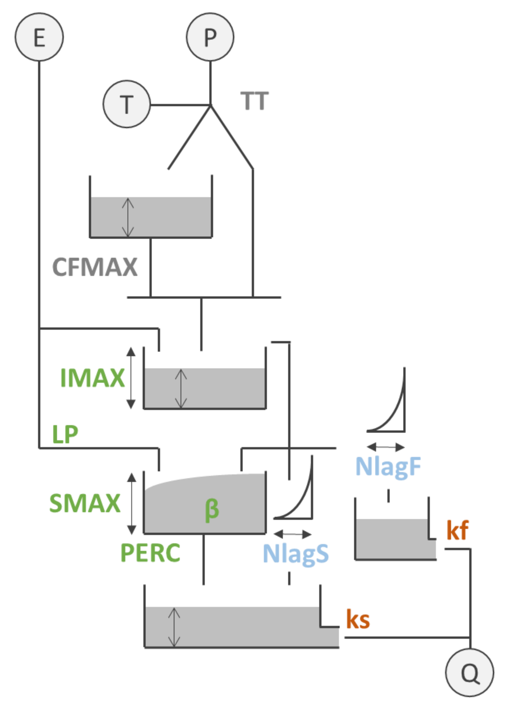
PENMAN[3]

ρ	[0, 1]
Smax	[1, 2000]
Def	[0, 250]
g	[0, 1]
a	[0, 1]



FLEX_IS[4,5]

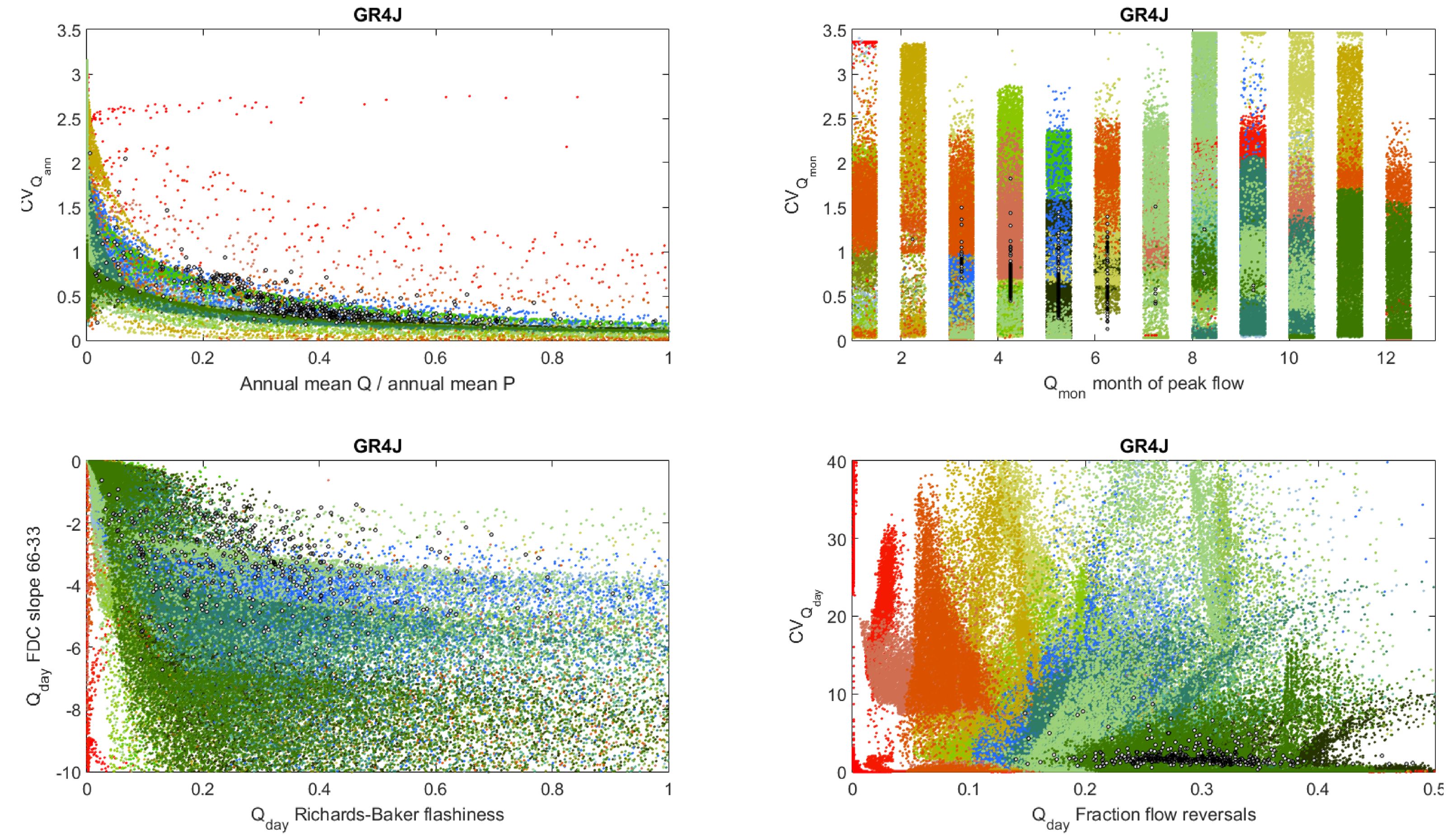
TT	[-3, 3]
CFMAX	[0.5, 20]
IMAX	[0, 5]
SMAX	[1, 2000]
β	[0, 7]
LP	[0, 1]
PERC	[0, 100]
D	[0, 1]
Kf	[0, 1]
Ks	[0, 1]
Nlagf	[0, 5]
Nlags	[0, 100]



These 3 models are chosen from a much longer list of models for brevity and their obvious differences in structure. GR4J and PENMAN have a limited number of parameters but contain some unique elements (e.g. water exchange, deficit store), while FLEX-IS is a more traditional RR-model with a larger number of parameters.

We use Latin-Hypercube sampling to generate minimum 5000 parameter sets for each model.

Forcing strongly controls model potential

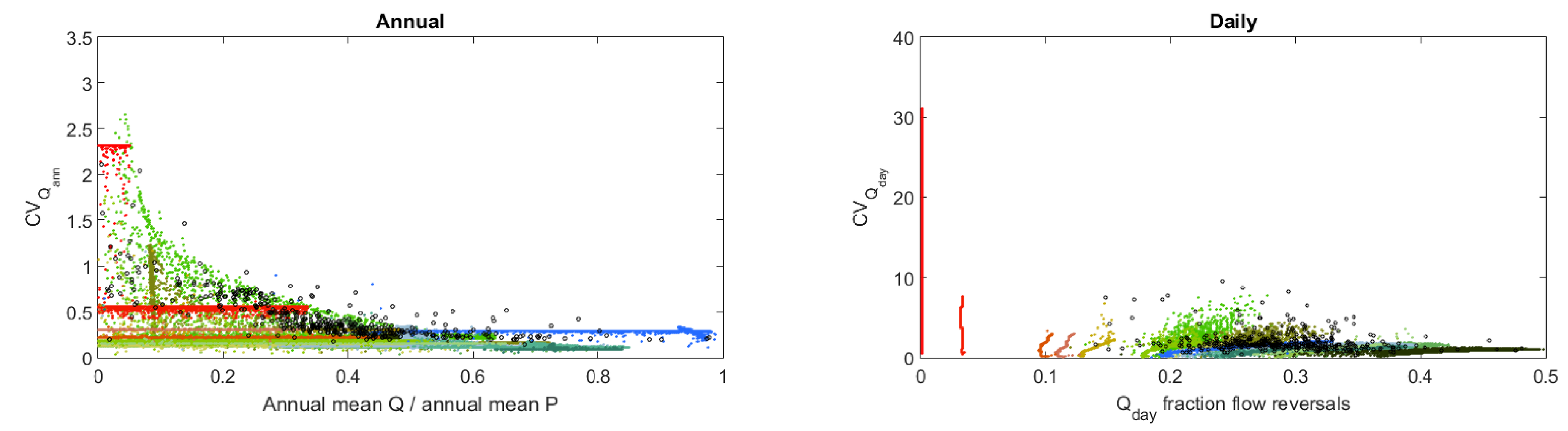


GR4J sampling (25000 parameter sets x 18 climates = 450000 samples) summarized as signature values. Black circles are observations from 410 MOPEX catchments.

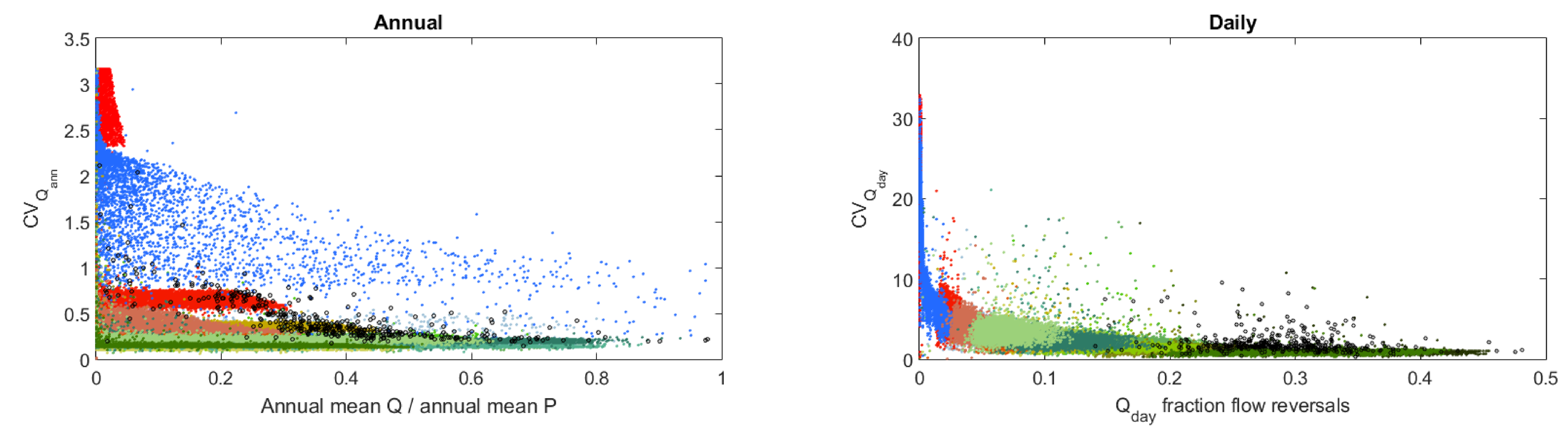
Top: climate forcing determines model potential - which regions of the output space a model can reach. Arid climates limit simulation potential more than wet ones (red regions tend to be smaller than green ones).

Bottom: PENMAN's deficit store enhances this effect.

FLEX-IS shows that more parameters don't necessarily increase model simulation potential.



PENMAN (top) and FLEX-IS (bottom) sampling (5000 parameter sets x 18 climates).



Limitations: number of parameter samples and models is too low. Both will be addressed in future work, allowing hypotheses about what makes models different.

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Climate clustering data (P, T, N, E):
CRU TS v3.23 - Harris, I., et al. (2014). http://doi.org/10.1002/joc.3711

Model forcing data (P): MSWEP - Beck, H. E., et al. (2017). http://doi.org/10.5194/hess-21-589-2017
Model forcing data (T): BEST - Berkely Earth. (2017). http://www.berkeleyearth.org
Model forcing data (E): USGS - USGS. (2017). https://earlywarning.usgs.gov/fews/product/81

[1] Peel, M. C., et al. (2007). http://doi.org/10.5194/hess-11-1633-2007
[2] Perrin, C., et al. (2003). http://doi.org/10.1016/S0022-1694(03)00225-7
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