EBERHARD KARLS
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EGU 2022 | Machine Learning for Climate Science (ITS2.7/AS5.2)

Conditional normalizing flow for predicting the occurrence of rare extreme events on long time scales

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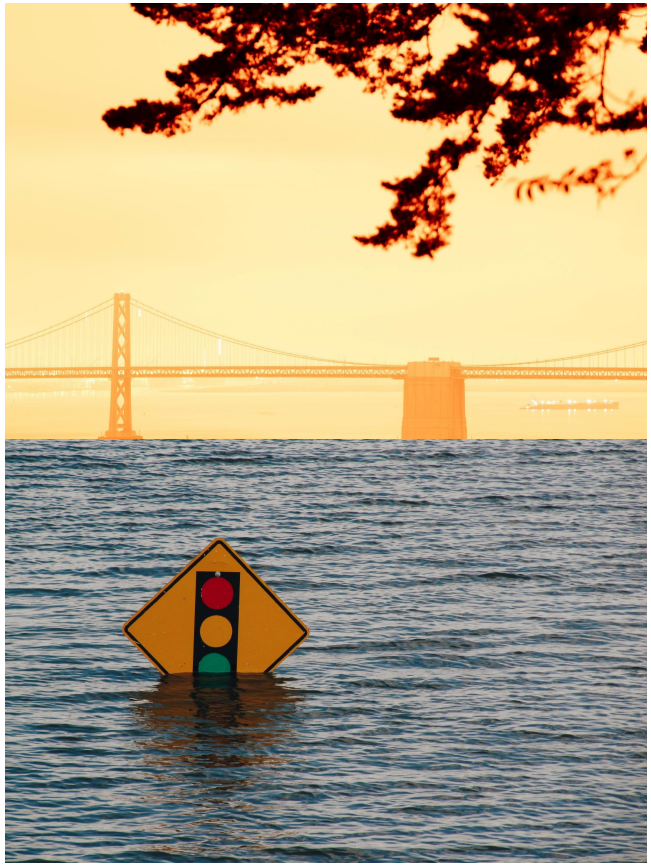
23.05.2022

Motivation



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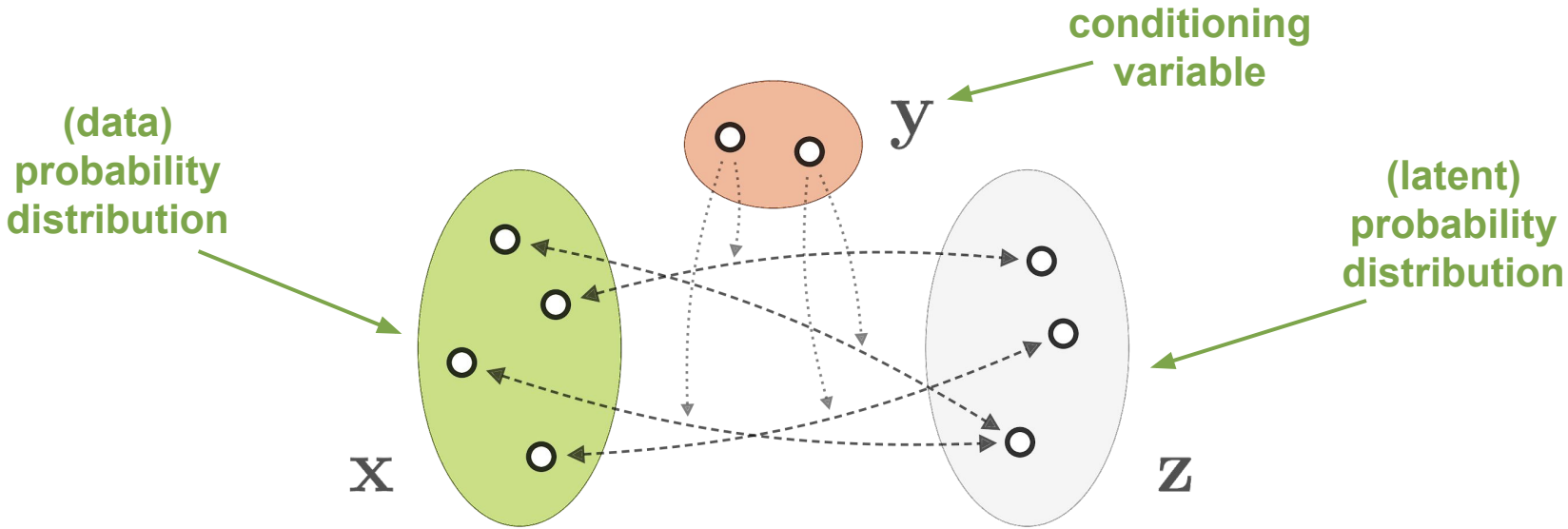
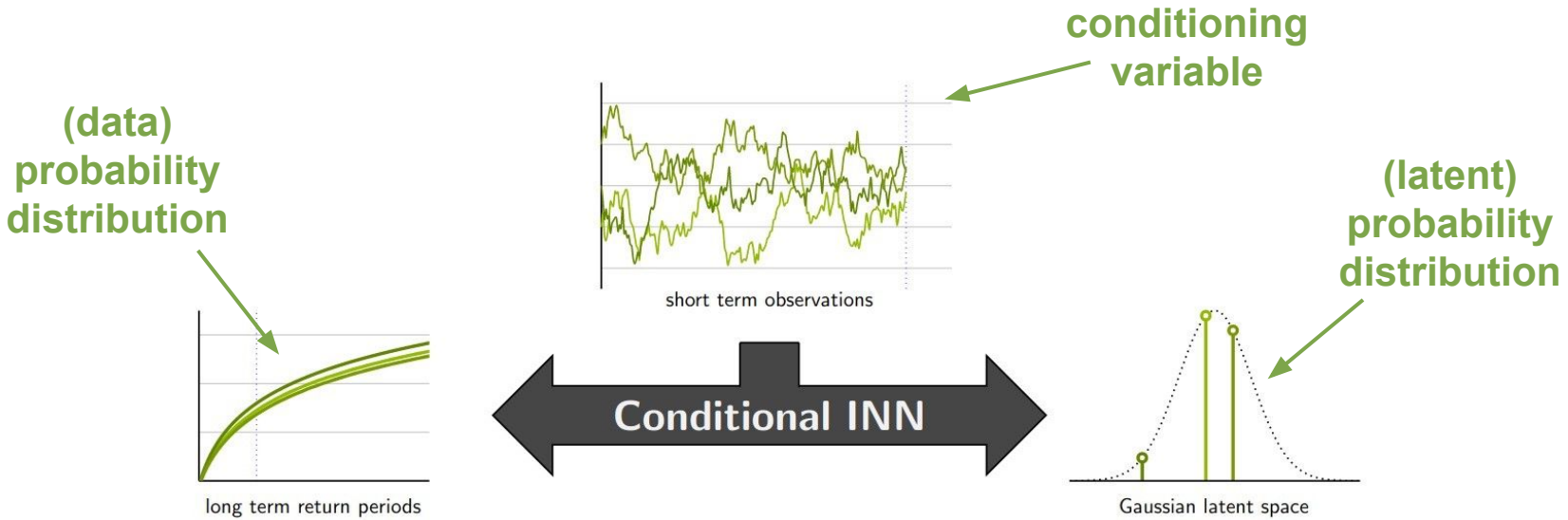
- Increasing **risk** of extreme climatic events
- Understanding & predicting extremes in **correlated dynamical systems** is challenging
- Only **short observation** periods
- Extreme value theory doesn't model **correlations, periodicities** and **non-stationary trends**

Can **normalizing flows** predict recurrence of rare events on **long timescales** better than classical methods, given only short observations?



mapping between **two distributions**

learn in one direction → generate samples in the other



Methods

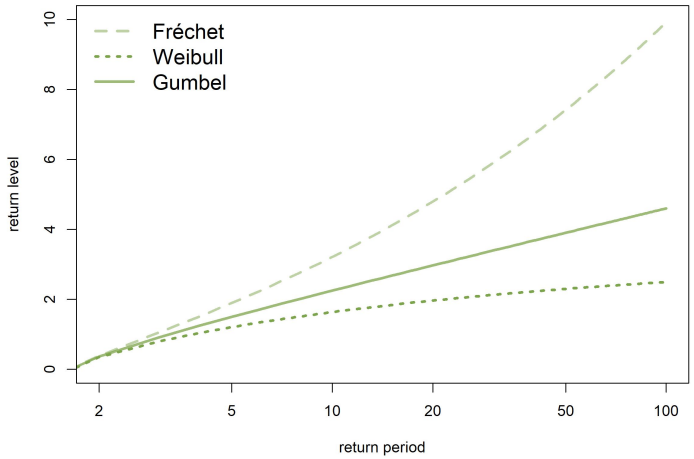
Statistics: **Mean return periods**

$$\mathbf{X} = (x_1, ..., x_N),\ x_i \geq x_{i+1}$$

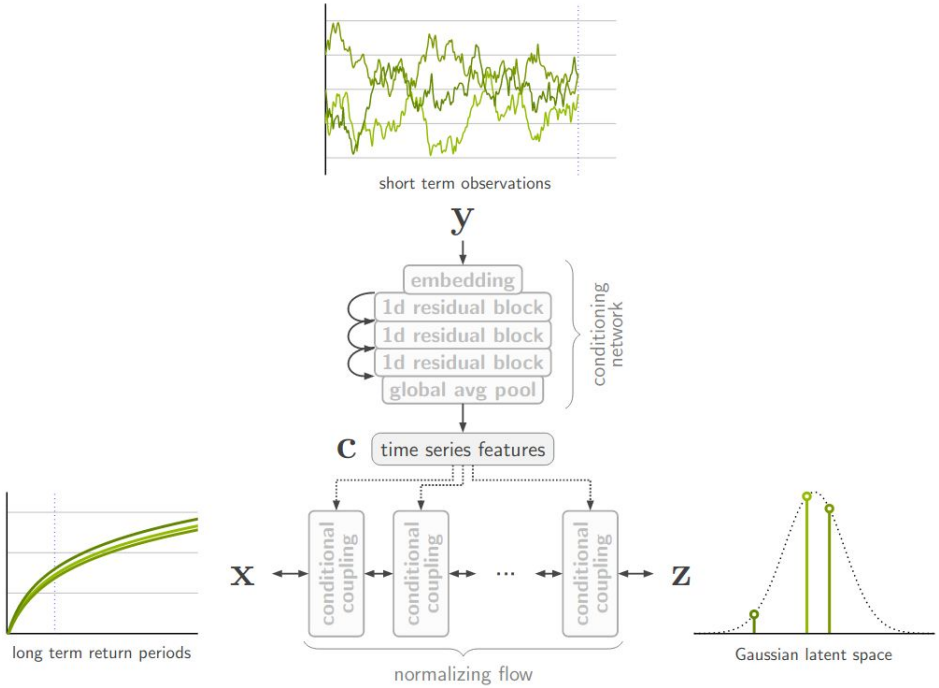
→ *events sorted by size*

$$\mathbf{R}(x_i) = 1/(P(x \geq x_i)) = \frac{N+1}{i}$$

→ *inverses of their ranks*



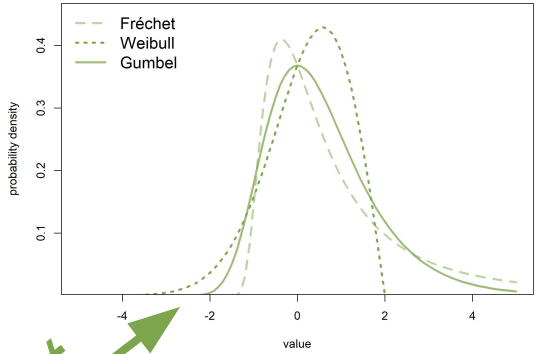
Network: **Conditional normalizing flow**

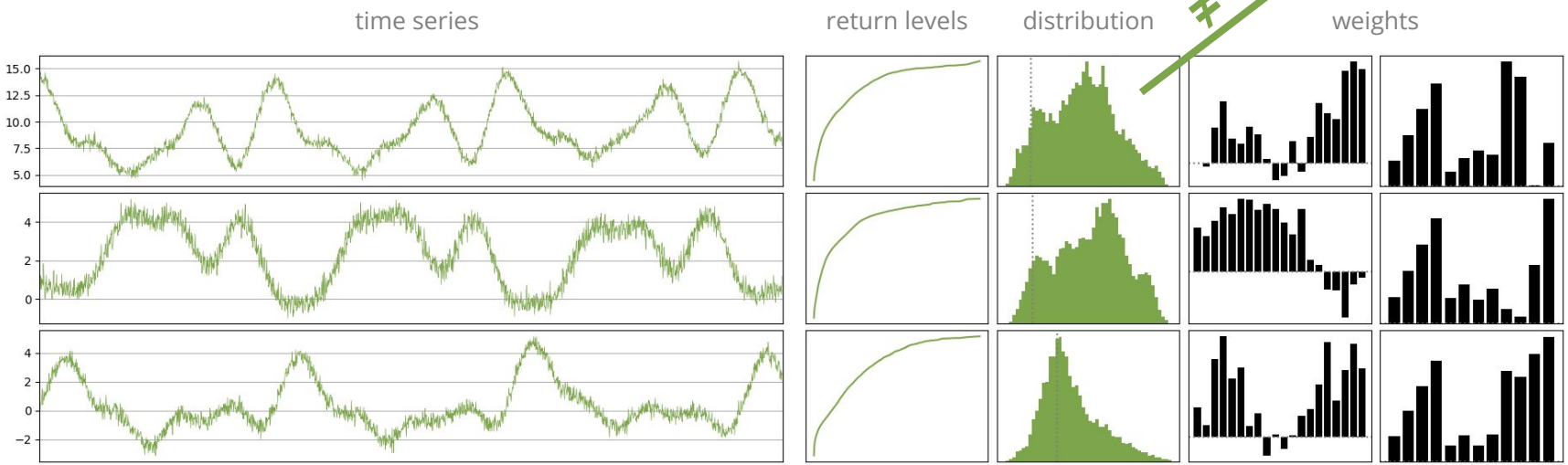


Data

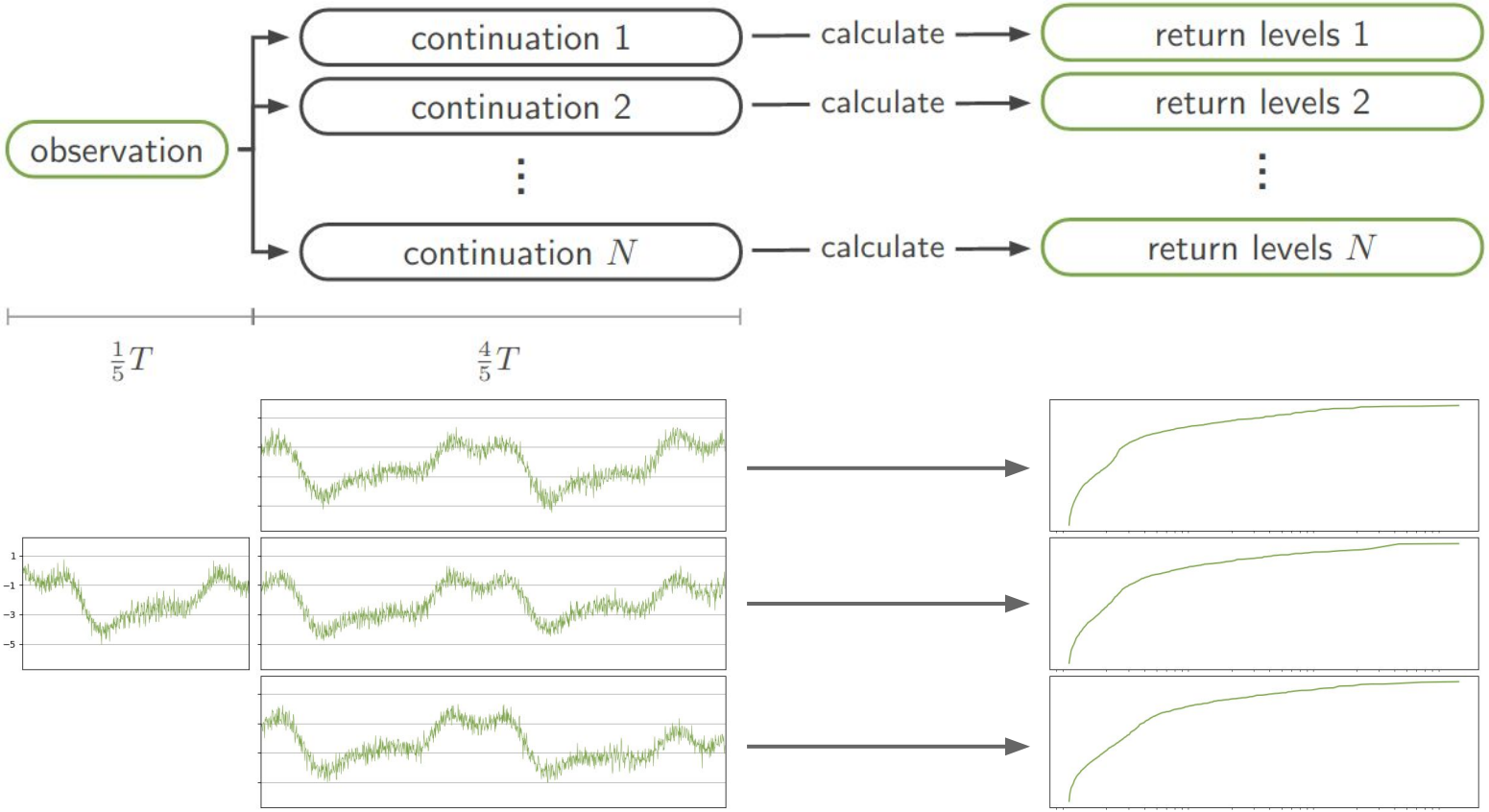
AR(p) model: $$X_t = \sum_{i=1}^{p} w_i X_{t-i} + \epsilon_t$$

with $$\epsilon_t = \sum_j \left(\alpha_j \sin\left(\omega_j t + \phi_j\right)\right) + \mathcal{N}(0, \tfrac{1}{3})$$

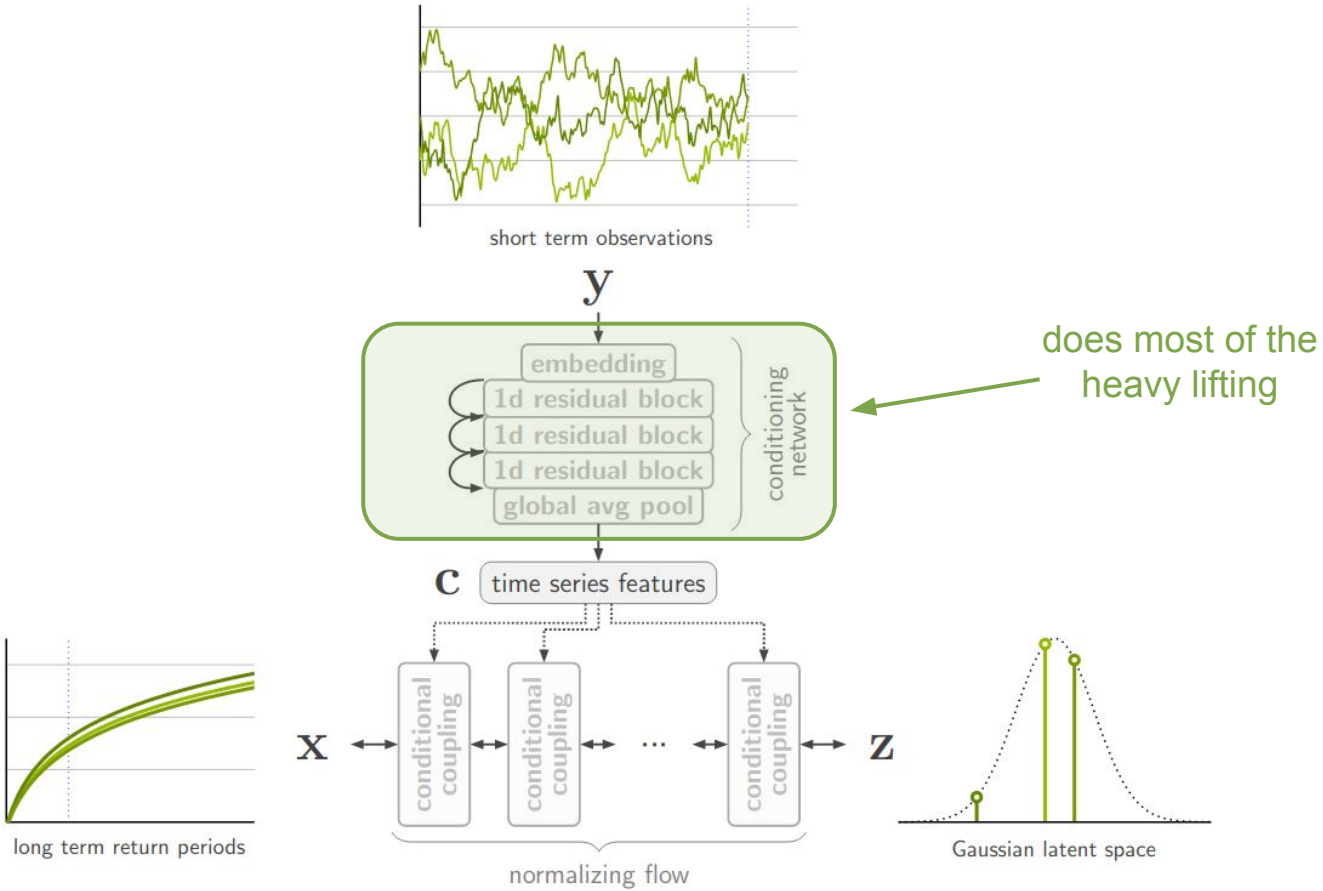




Data

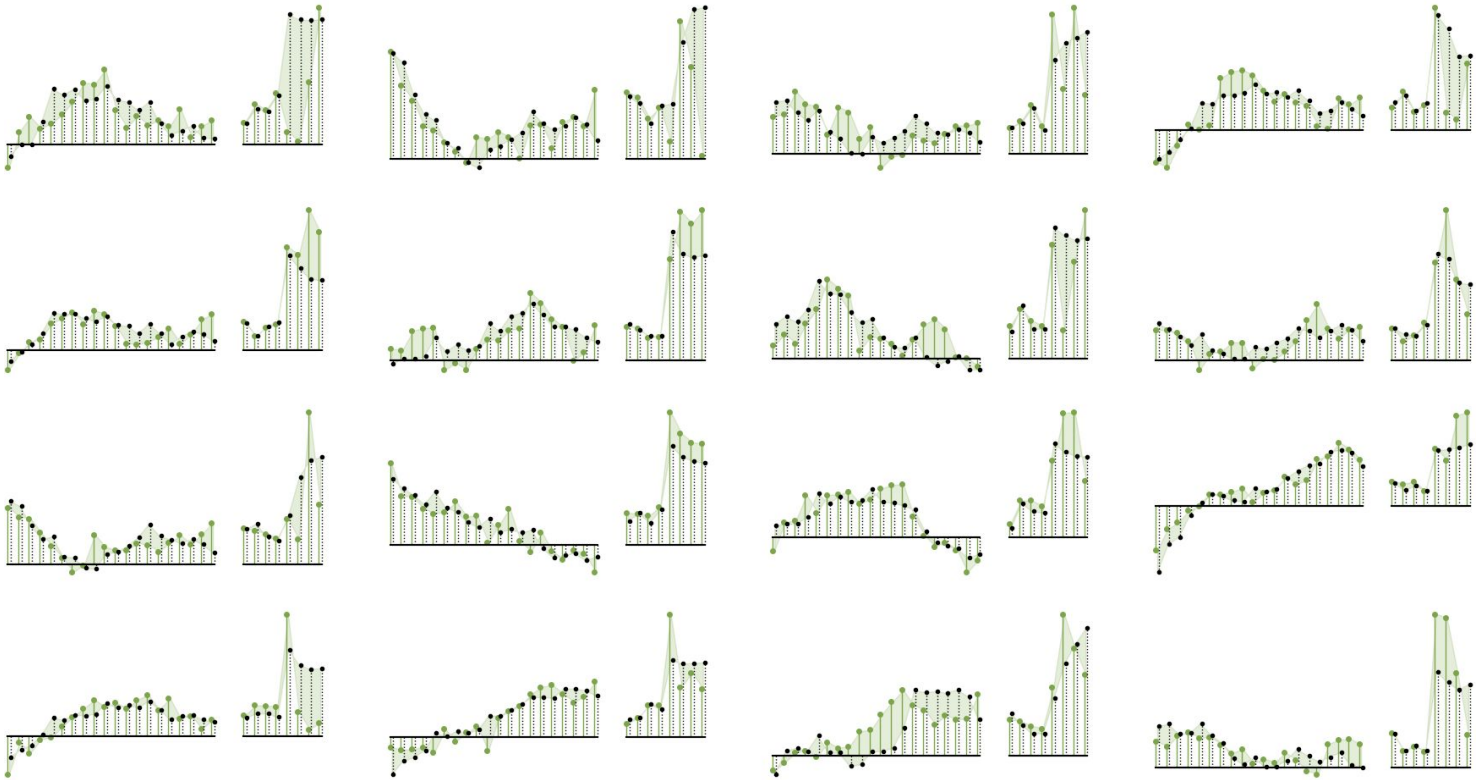

observation
continuation 1
continuation 2
continuation N
calculate
calculate
calculate
return levels 1
return levels 2
return levels N
$\frac{1}{5}T$
$\frac{4}{5}T$

Preliminary results



Preliminary results

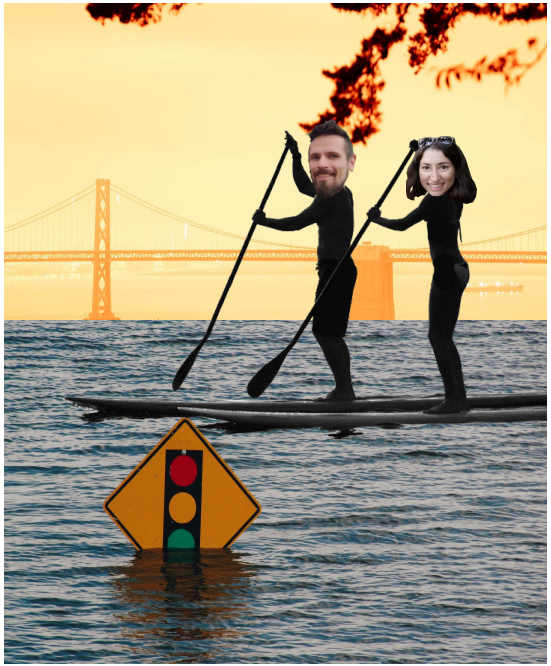
conditioning network pre-training: **learn to predict coefficients of AR(p) data model**



ground truth vs predicted

Conclusion and Outlook

- Summary
  - return levels can be modelled by normalizing flow
  - results and comparison to EVT to follow
- Directions
  - other temporal models
  - events other than maxima
  - consider spatial extent of extremes



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or find us around the conference :)