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Ecosystem Insights through Extreme Values: A Fresh Look at Meteorological Drivers

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Research Gap

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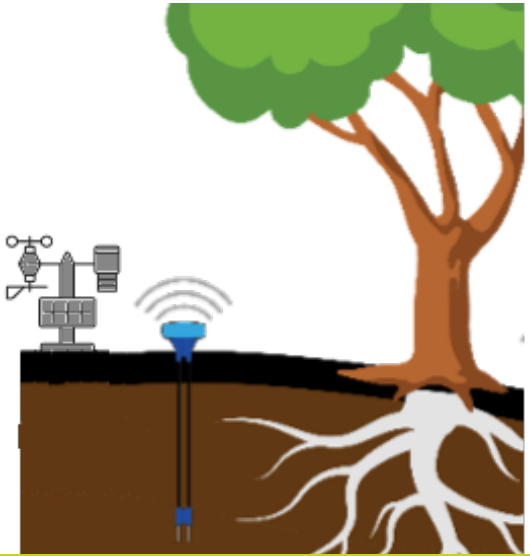
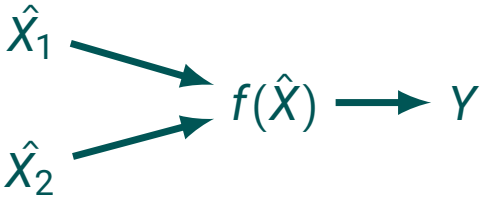
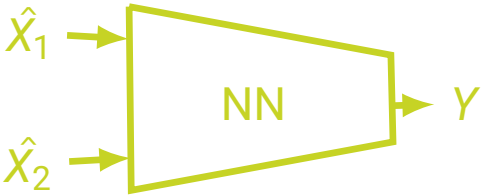
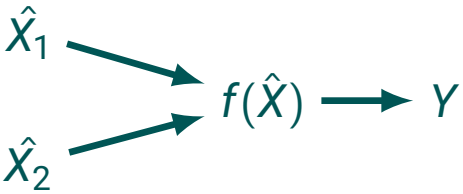
- The main purpose of data-driven models is predicting some response to specific inputs.
- For example, the amount of CO_2 uptake given meteorological forcings, or the amount of evaporation in a situation.
- However, in many disciplines researchers also build data- driven models in order to **identify the correct mechanism**.



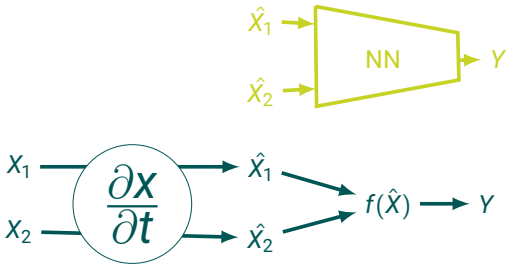


- When we build a data-driven model, we want to identify a mechanism $f(\hat{X})$ that determines some outcome Y from some drivers X_1 and X_2.

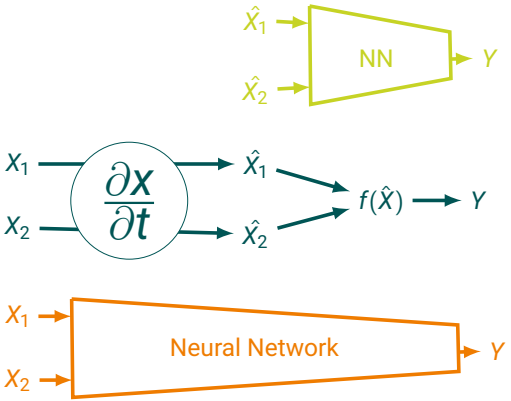




- We can understand this mechanism by training a neural network.



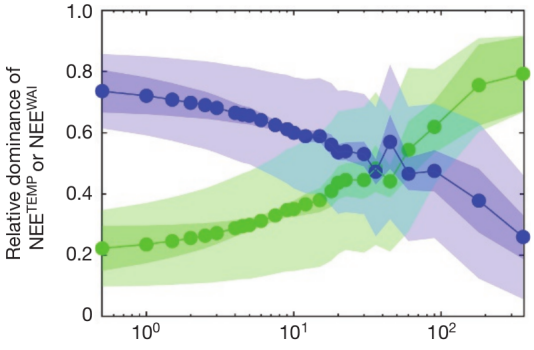
- However, in real applications, we do not measure the inputs directly when they enter the mechanism.
- Instead, the variables interact between the point we measure and the point of entering the mechanism.



- Therefore, when building a data-driven model, we model the combination of the dynamic system and the target mechanism.
- **Resulting in a biased prediction**

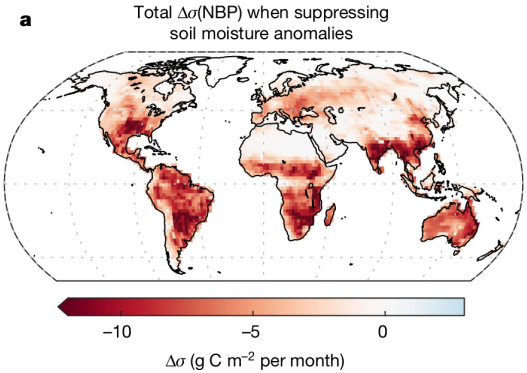
Where is this Relevant?

- (Jung et al., 2017) find that plant productivity is locally mostly influenced by water availability but globally by temperature.



Where is this Relevant?

- (Jung et al., 2017) find that plant productivity is locally mostly influenced by water availability but globally by temperature.
- (Seneviratne et al., 2013) find that global models lose more than 80% of the variability in plant productivity when supressing the variability in soil moisture.



Where is this Relevant?

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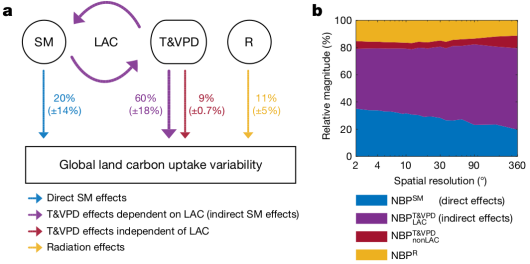
- (Jung et al., 2017) find that plant productivity is locally mostly influenced by water availability but globally by temperature.
- (Seneviratne et al., 2013) find that global models lose more than 80% of the variability in plant productivity when supressing the variability in soil moisture.
- (Humphrey et al., 2021) claim that this difference is due to the land–atmosphere feedback.



We Propose

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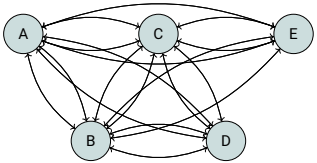
We propose to train only on extreme values.

Why?



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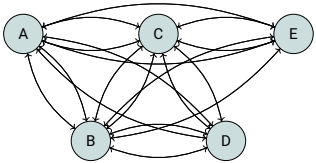

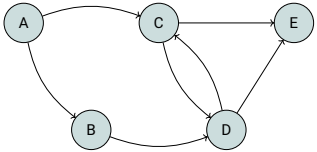

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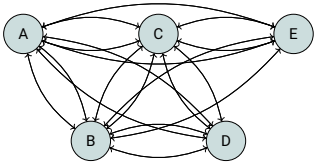
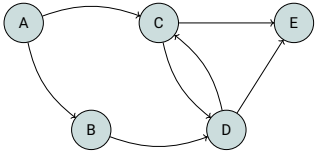
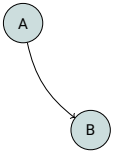
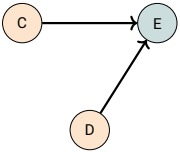
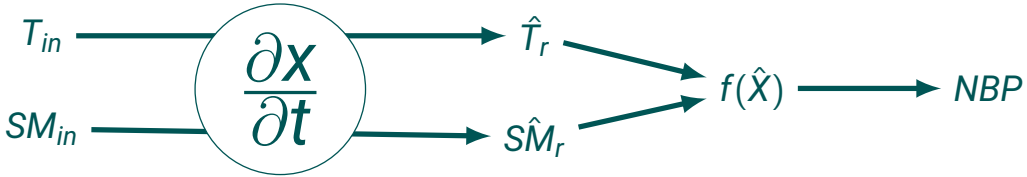








Does it work?



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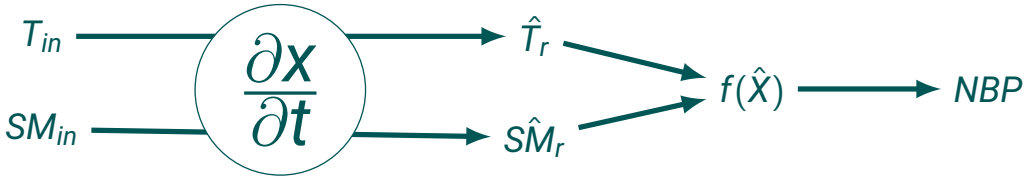

$$NBP = \alpha T_r + \beta SM_r + \gamma + \epsilon$$

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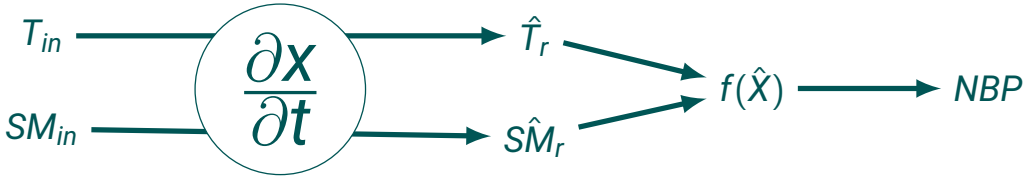

$$T_r = T_{in} - \frac{C_T}{1 + e^{-(SM_{in}T_{in} - C_0)}}$$

$$SM_r = SM_{in} - \frac{C_{SM}}{1 + e^{-(SM_{in}T_{in} - C_0)}}$$

$$NBP = \alpha T_r + \beta SM_r + \gamma + \epsilon$$

Theoretical Result

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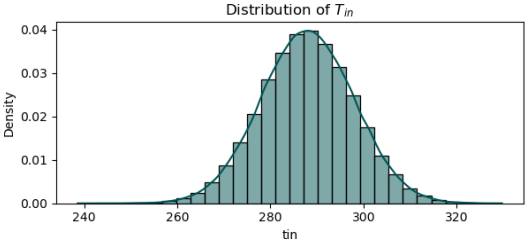
If we can make reasonable assumptions, a linear regression on T_{in} and SM_{in} does not return the correct values α and β but

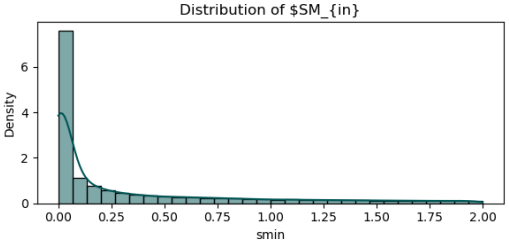
$$\alpha^* = \frac{\alpha}{1 - C_T SM_{in}} \quad \textit{and} \quad \beta^* = \frac{\beta}{1 - C_{SM} T_{in}}.$$

However, if we train only on extreme values, we find

$$\alpha^* = \alpha \quad \textit{and} \quad \beta^* = \beta.$$

Empirical Results





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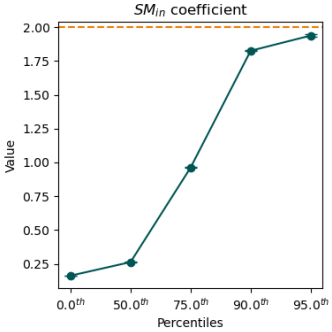

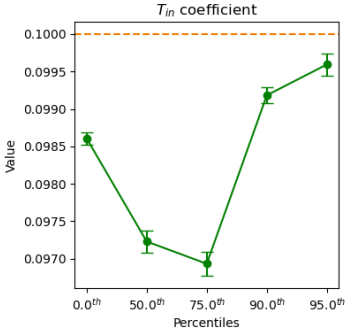

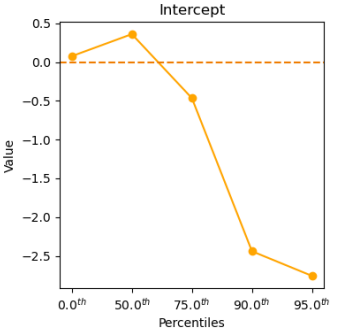

Conclusion and Future Work

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- Training on extreme values recovers the true mechanism while training on all values does not.

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- For the example we showed this theoretically as well as empirically.

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- Training on extreme values recovers the true mechanism while training on all values does not.
- For the example we showed this theoretically as well as empirically.
- The next step is to test this with more realistic models and, afterward, on real data.