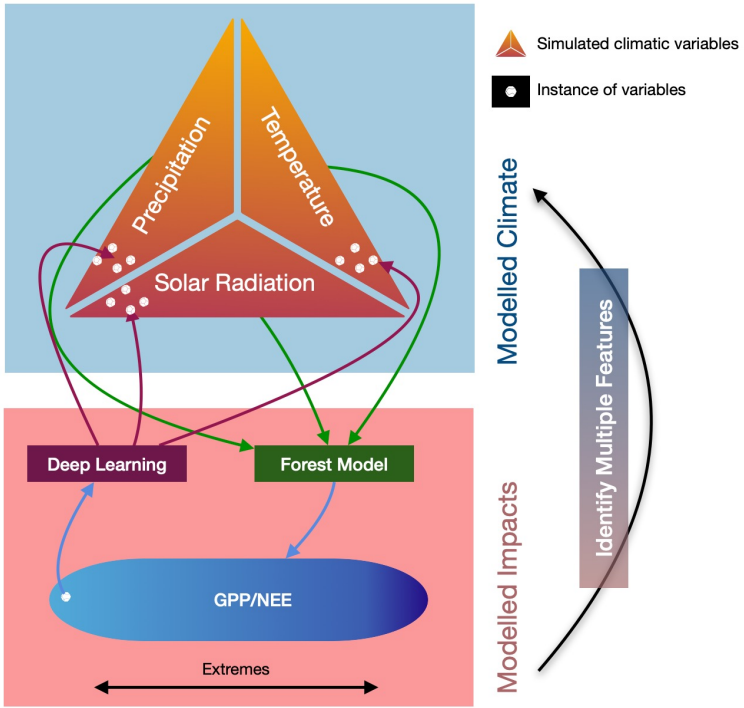

Identifying drivers of extreme reduction in carbon uptake of forests using interpretable machine learning

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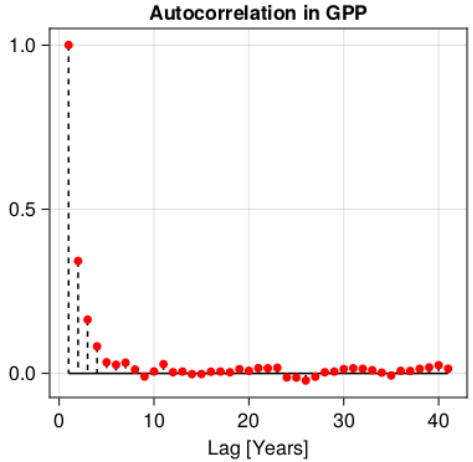
Location and data

- Hainich beech forest, Germany
- Weather generator (AWE-GEN)
- 200,000 years of climate simulation
  - Precipitation
  - Temperature
  - Solar radiation
- Temporal resolution - daily
- Forest model (FORMIND)
- GPP as yearly output



- Deep Learning input-output (X,Y) pair
  - Input = 4*365 x 3
  - Output = 1

Neural Network Architecture

- Self Explanatory Neural Network (SENN)

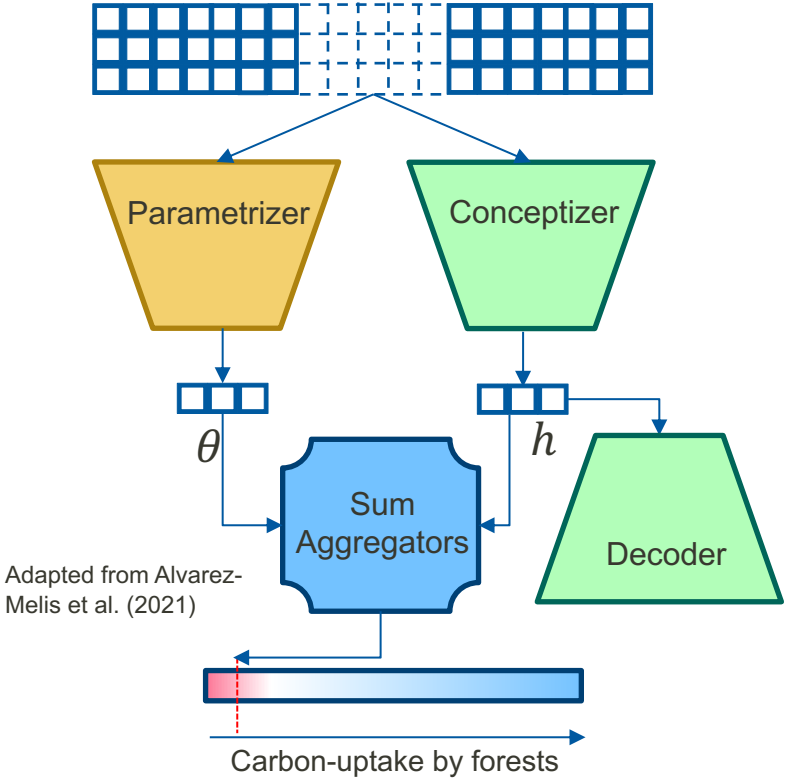
$$f(x) = \sum_{i}^{k} \theta(x)_i h(x)_i$$

- For small changes in concepts, parameters don't change much.
- Loss Function

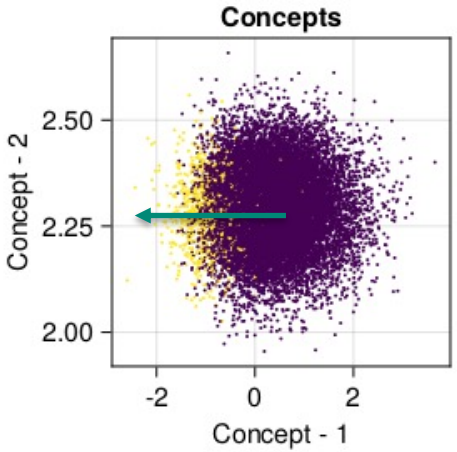
$$\mathcal{L}_y(f(x), y) + \lambda \mathcal{L}_\theta(f(x)) + \eta \mathcal{L}_h(x, \hat{x})$$

- Hilbert-schmidt independence criterion (HSIC)

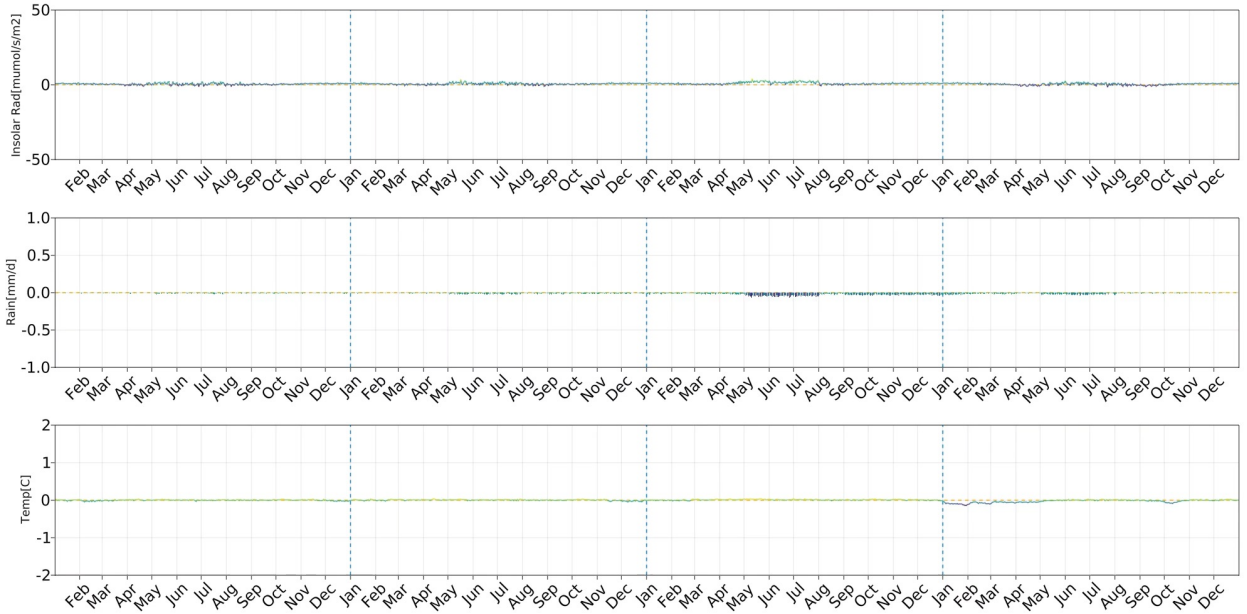
  Independent concepts/parameters



Results



- Traversing the concept space
- Difference from the mean climate



Conclusions

- Deep learning can model processes involving long-term memory effects and non-linear driver interactions
- SENN is able to extract explainable concepts responsible for forest mortality
- HSIC loss can disentangle the concept space

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