"USING EXPLAINABLE NEURAL NETWORKS FOR COMPARING HISTORICAL CLIMATE MODEL SIMULATIONS"

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The opportunity

Global climate models are now being generated at higher and higher resolutions and thus simulating more complex Earth system interactions. To assess this vast amount of data, scientists are turning to an increasing number of advanced statistical methods, such as neural networks.

Previous studies have found that neural networks use regional patterns to predict simple characteristics of climate data (e.g., identify the year of a map)

Our approach

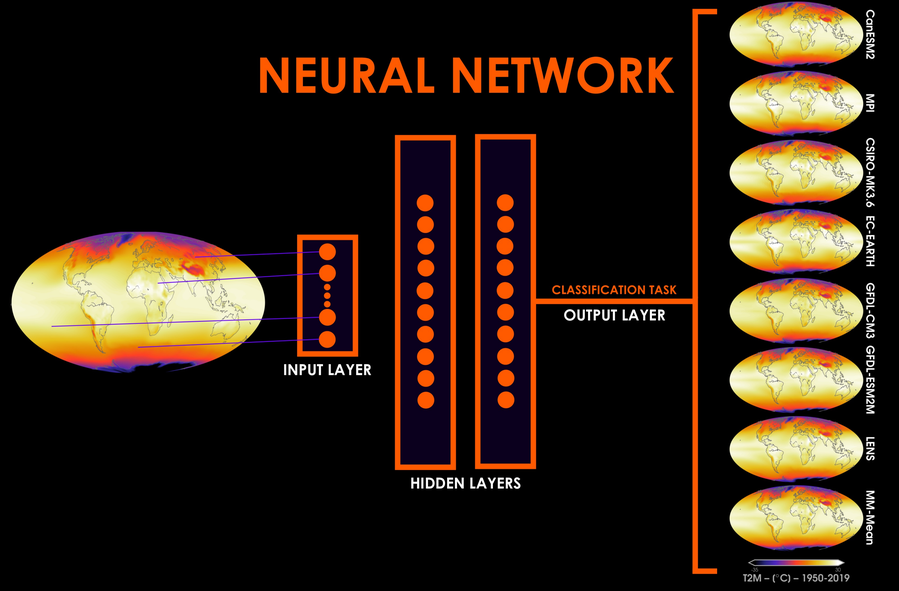
- Train a shallow artificial neural network (ANN) on maps of temperature from a collection of climate model large ensembles (MMLEA/SMILE Archive – CMIP5)
- ANN's task is to classify which climate model produced each temperature map – 8 classes (100% accuracy)
- Input observations to test which climate model is classified for every year from 1950 to 2019
- Use layer-wise relevance propagation (LRP) to understand where the ANN is looking in order to make a prediction

The conclusions

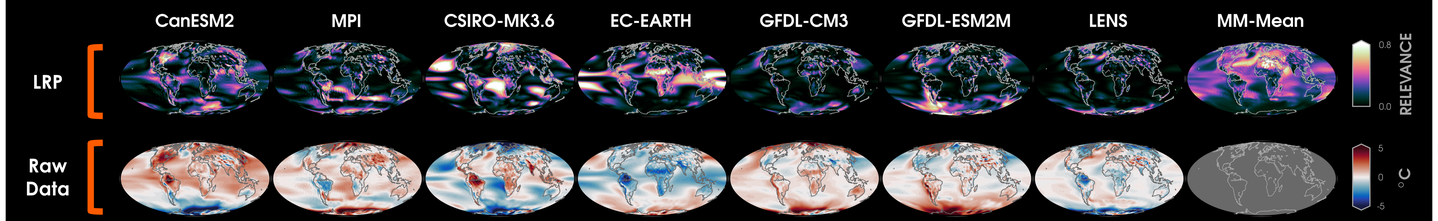
After training on climate model data, the neural network classifies input (global) maps from observations (ERA5-BE/20CRv3 reanalysis) as the multi-model mean ensemble

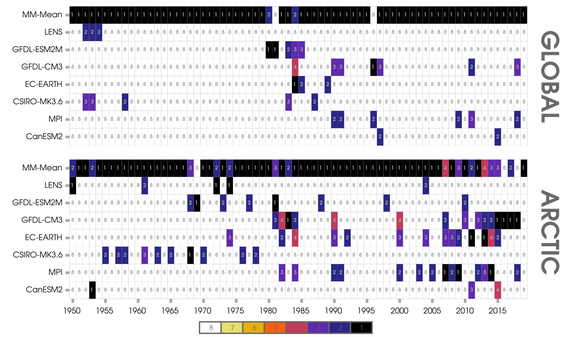
The neural network architecture can be used for climate model comparison/evaluation in regions with known large biases, such as over the Arctic or the Southern Ocean

Explainable neural networks can be used to **identify unique differences** in temperature simulated between global climate model large ensembles



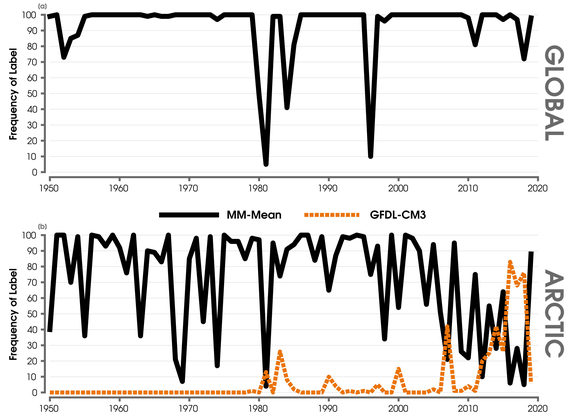
What regions are relevant for the neural network to classify each global climate model?





RELATIVE MODEL CHOICE

A softmax activation function is applied to the final layer of the ANN in order to transform the class probabilities so that they sum to one. We then use the order of these likelihoods to rank the choice of climate model for each map from observations (where 1 = largest predicted probability).



Frequency of the ANN classification after considering 100 different combinations of training and testing data (ensemble members for each climate model) and unique random initialization seeds