Emulating Integrated Assessment Models with Deep Learning

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Overview

Motivation: Integrated assessment models like the Global Change Assessment Model (GCAM) are invaluable to policy makers for understanding the complex and intersecting effects of climate on energy, water, land and other sectors, but are computationally intensive.

Goal: Emulate GCAM accurately and computationally efficiently.

Approach: Train a deep learning model on an existing ensemble of GCAM runs, producing an efficient and accurate emulator.

Background

GCAM is a market equilibrium model that models the interaction between the five major sectors: water, energy, land, climate, and socio-economics.

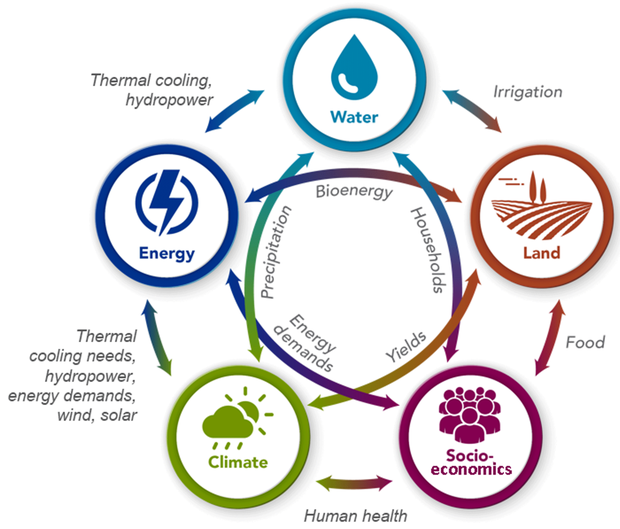

Figure 1: Relationship between sectors.

Regions are divided differently based on which sector they belong to.

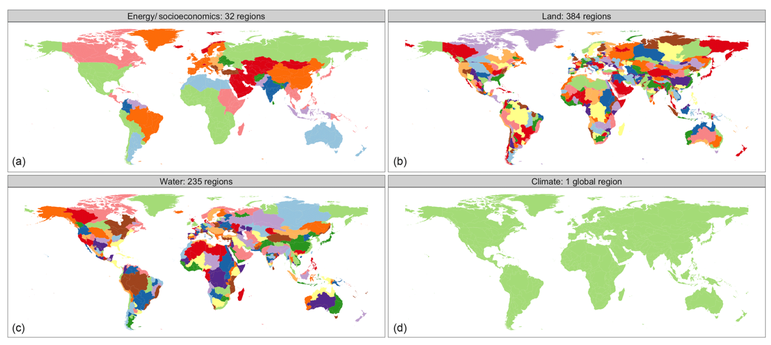

Figure 2: Region boundaries for energy and economy (a), land (b), water (c), and climate

Model

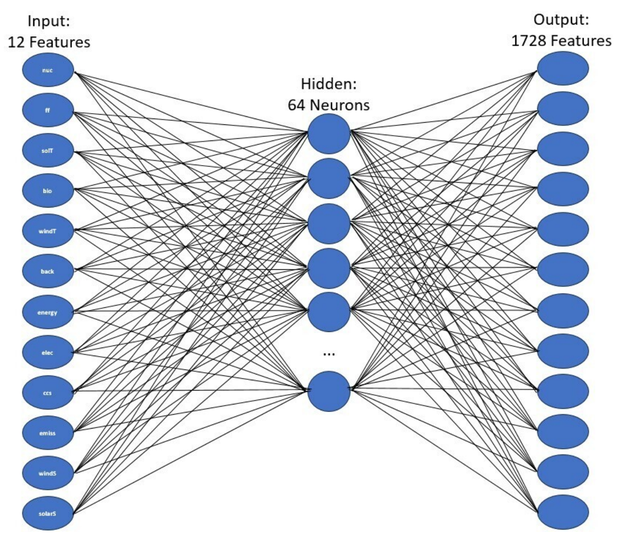

Figure 3: Single hidden layer neural network.

Experimental Setup

Inputs: 12 dim. binary vectors, encoding high/low values for the following:

- emissions
- fossil fuel costs
- bio energy
- nuclear
- wind tech and storage
- solar tech and storage
- electrification and energy

Outputs: 9 features (5 crops, water consumption, solar, wind and other energy generation) across 6 different years in 5 year timestamps from 2025 to 2050 across 32 regions.

Dataset: We split 4096 GCAM runs into training, validation and test sets at a 80%-10%-10% ratio.

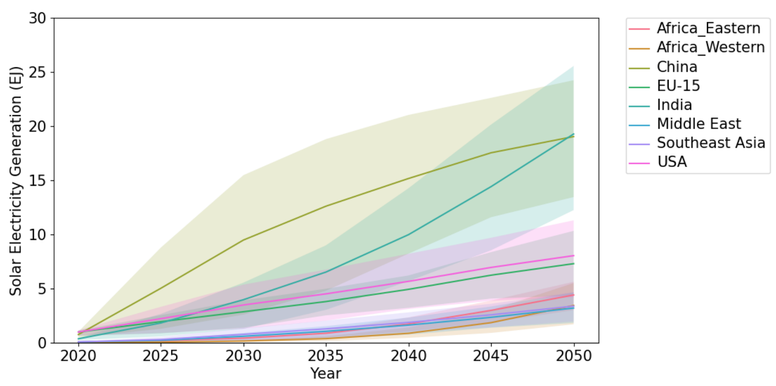

Figure 4: Solar and wind generation by region averaged across the top 5 percent of scenarios

Results & Analysis

Is one feature/region hardest to predict?

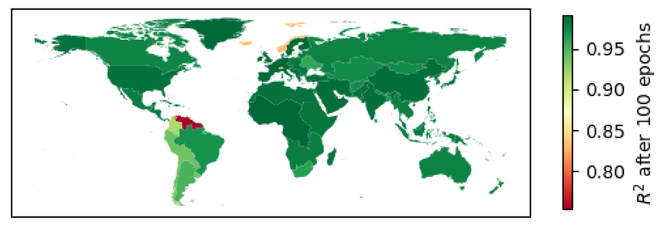

Figure 5: $\boldsymbol{R^2}$ across features after 100 epochs.

- The worst performance of the emulator is for South America, followed by Europe. Africa is the most accurate.

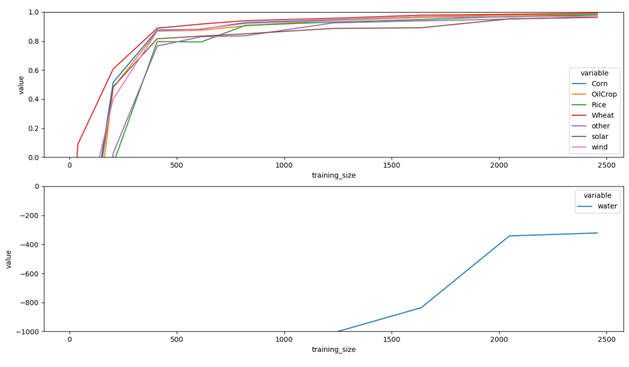

Figure 6: $\boldsymbol{R^2}$ across regions after 100 epochs.

- Nearly all features are performing extremely well. Water consumption lags behind.

Future Work

- Increase accuracy for Latin America and Europe regions and water consumption
- Expand the input variability across new sectors
- Expand predictions to include more years and features
- Perform sensitivity testing to find correlations between specific inputs and outputs