

Deep Learning for Downscaling

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Today's Paper

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Reading Guide

For our upcoming class, please read “DeepSD: Generating High Resolution Climate Change Projections...” This paper presents a radically different philosophy from the Steinschneider paper.

Your goal is to understand its “data-driven” approach. Think of this model not as a “physics simulator” but as an “image processing” tool.

What to Focus On

- **The Core Analogy:** The entire paper is built on an analogy: “Downscaling is like ‘Single Image Super-Resolution’.” Make sure you understand this. What is the “low-resolution image”? What is the “high-resolution image”?
- **The “Black Box”:** The model uses a Convolutional Neural Network (CNN). You do not need to understand how a CNN works in detail. You only need to understand what it does: it learns a statistical mapping (a function) to get from the “low-res” input to the “high-res” output.
- **Training vs. Projection:** Pay very close attention to Figure 1 and Section 3.
 - **Training:** What data does the model learn from? (Hint: It’s a pair of datasets).
 - **Projection:** What data do you feed into the model to get a future high-res climate?

Key Concepts to Consider

- **“Data-Driven”:** This model is “data-driven,” not “process-informed.” What does that mean? What does it gain by not imposing physical rules? What might it lose?
- **Spatial vs. Temporal:** This method treats climate data as an “image” (a spatial map). How does it handle the sequence of days (the temporal aspect)? Does it model it explicitly, or at all?
- **Stationarity:** The model learns a relationship from historical data. It then applies that same relationship to future GCM output. What is the core assumption it’s making about the future?

Questions for Preparation

Please come to class prepared to discuss and share your answers to these three questions:

1. Why treat downscaling as an “image processing” (super-resolution) problem? What specific climate features (e.g., spatial patterns, extremes) does this method gain that a simple, single-point method (like QQ-mapping) would miss?
2. The Steinschneider paper distrusted the GCM’s dynamics and replaced them. What does the DeepSD model trust about the GCM? And what part does it distrust (or “correct”)?
3. How does this model generate a future projection (e.g., for 2080)? What is the single biggest assumption it makes about the relationship between low-res and high-res climate for this to be a valid approach?

References

Bibliography

- [1] T. Vandal, E. Kodra, S. Ganguly, A. Michaelis, R. Nemani, and A. R. Ganguly, “DeepSD: Generating High Resolution Climate Change Projections through Single Image Super-Resolution.” Accessed: Sep. 26, 2024. [Online]. Available: <http://arxiv.org/abs/1703.03126>