Bringing deep learning to the plate of climate scientists for downscaling

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Importance of machine learning for climate

- **Complexity of Climate Data:** Climate data is inherently multi-dimensional and non-linear, capturing a vast array of atmospheric, oceanic, terrestrial, and even extraterrestrial variables. It is influenced by multiple physical and biological factors that interact in complex ways, making it challenging to analyze using traditional statistical methods.
Importance of machine learning for climate

- **Machine Learning's Capability:** Machine Learning algorithms, especially those utilizing deep learning, excel at capturing complex, non-linear relationships. They can learn from massive amounts of data, recognizing intricate patterns and making accurate predictions.

Importance of machine learning for climate

- **Performance Advantage:** Studies have consistently shown that ML algorithms often outperform traditional models in predicting climate patterns. This improved accuracy can be critical in developing effective responses to climate change.

Background: Key Terms and Intersections

- **Urban Digital Twin**: An Urban Digital Twin is a virtual replica of a city, replicating its physical properties, systems, and processes digitally. These twins serve as a dynamic, real-time model of the city, allowing for simulation, analysis, and prediction of urban phenomena.
What do we need for urban digital twins?

- High resolution (< 500 m) datasets of existing climate datasets
- Development of algorithms facilitating the development of high resolution datasets - downscaling or super-resolution
- Development of novel datasets for urban digital twins
- Merging existing physical modelling with machine learning to develop high resolution forecasts
We first need to develop supervised learning datasets. The solution is being provided by DownScaleBench.
DownScaleBench for developing and applying a deep learning based urban climate downscaling

Next, we need state of the art models to perform super-resolution/downscaling. The solution is being provided by ClimateDownscaleSuite
ClimateDownscaleSuite: Unifying deep learning models for weather and climate downscaling

Singh et al, manuscript in preparation
ClimateDownscaleSuite applied to VIIRS to DMSP night time lights data transformation

Singh et al, manuscript in preparation
We also need state of the art novel methods to fuse station datasets into downscaling algorithms. MeteoGAN is the answer.
MeteoGAN for urban digital twins
Thank you