# UT-MeteoGAN: A foundation AI Model for High Resolution weather and climate applications

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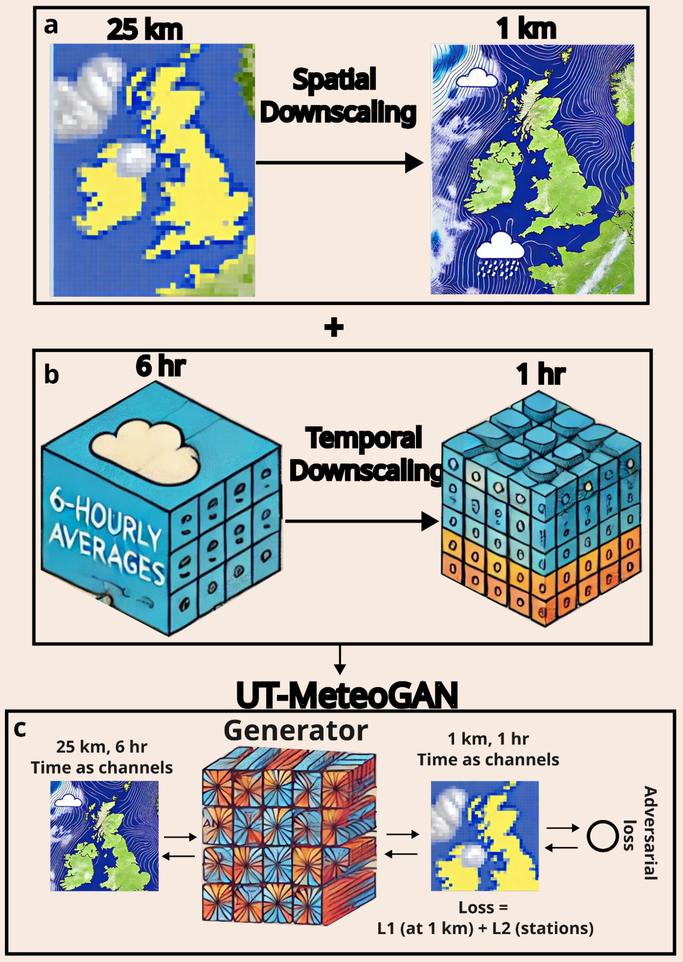
## Introduction

We present UT-MeteoGAN, an advanced AI-driven model designed for high-resolution numerical weather and climate prediction. UT-MeteoGAN enhances prediction accuracy and spatial resolution by transitioning from traditional Super Resolution Convolutional Neural Networks to the Swin Transformer architecture, while employing adversarial, station and physics-informed loss to refine its outputs. The model can peform cutting-edge data assimilation, incorporating station observations directly into the training process, significantly boosting forecast reliability. In addition to its ability to do data assimilation, it can generate high-resolution gridded predictions. UT-MeteoGAN excels in a variety of applications, including downscaling from coarser global models, and regional AI-based numerical weather prediction (NWP). The model can also complement existing AI NWP systems by adding more physically consistent components, strengthening forecast robustness. UT-MeteoGAN incorporates both physics-informed and physics-inspired mechanisms, such as diffusion-based methods, to further enhance its predictive capabilities. During a comprehensive case study over the continental United States, UT-MeteoGAN provided 36-hour lead forecasts at a 1-km spatial and 1-hour temporal resolution, demonstrating its ability to produce high-resolution outputs even in regions with limited data. By utilizing gridded ground truth observations alongside station data, UT-MeteoGAN consistently delivered forecasts that rivaled or outperformed existing models, offering fast and accurate predictions and was employed at World Meteorological Organization Research Demonstration Project (RDP) for Paris Olympics 2024. The model's development and deployment are supported by NVIDIA H100 GPUs available at the Texas Advanced Computing Center, ensuring scalability for operational use. UT-MeteoGAN represents a significant advancement in numerical weather and climate prediction, offering a robust, scalable solution for precise and timely forecasting. Its success in the continental U.S. highlights its potential for broader adoption across diverse meteorological and climate applications worldwide.

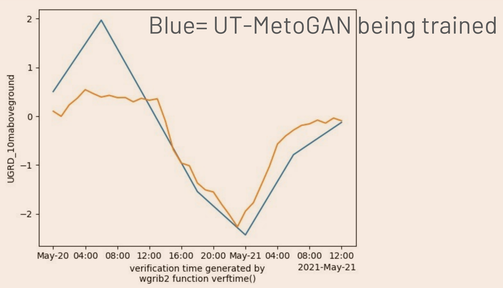
## UT-MeteoGAN Technical details

- Input: Graphcast global 36 hr forecasts (25 km spatial resolution, 6 hourly averages)
- Target: 1 km 1 hr NOAA AORC (https://registry.opendata.aws/noaa-nws-aorc/ )
- Model: SRGAN
- Variables: precipitation, surface air temperature, u and v surface winds
- Trained over Washington DC, transfer learning for Paris

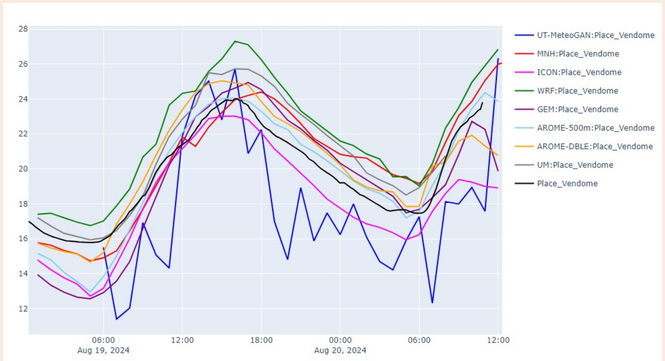
## UT-MeteoGAN architecture



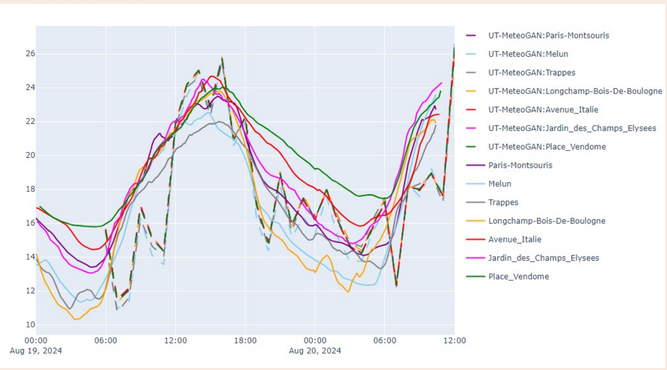

## UT-MeteoGAN Cal/Val




## Paris Olympics 2024




Aug 19 2024 forecast




## Ongoing research

Training UT-MeteoGAN with the entire Continental United States NOAA AORC data

## References

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