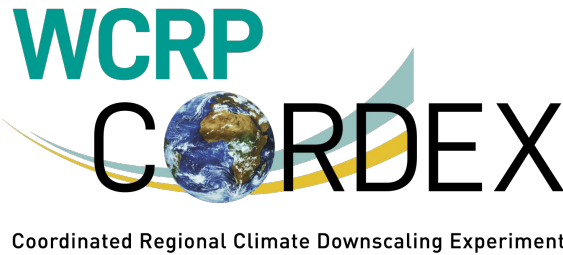
# Bringing deep learning to the plate of climate scientists for downscaling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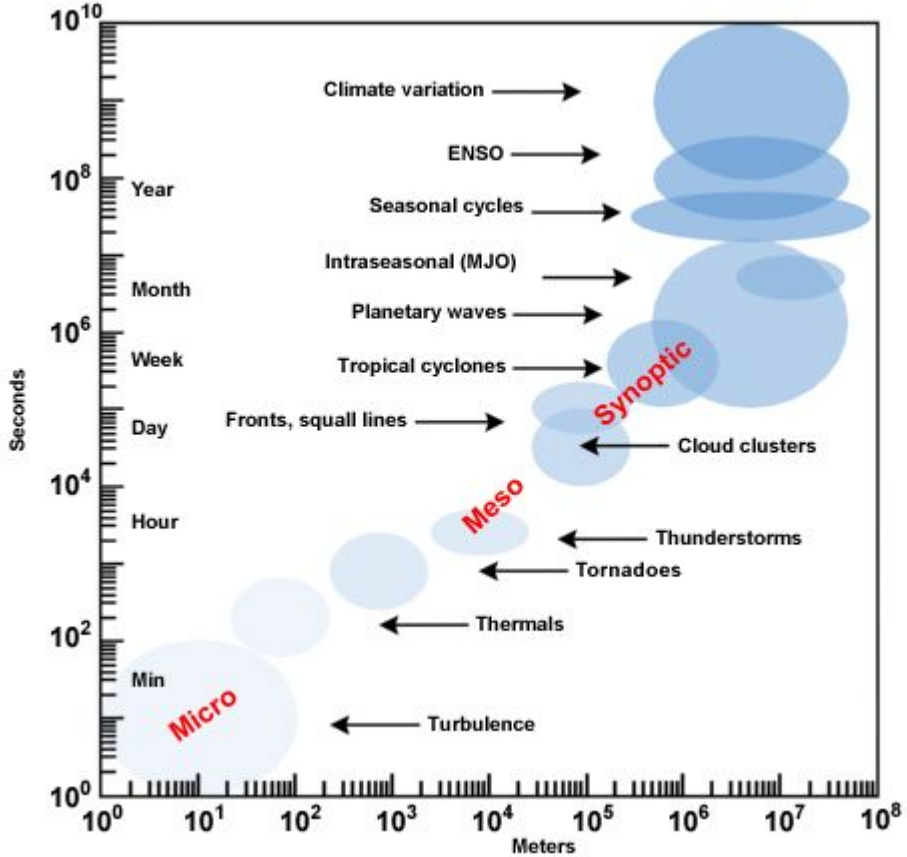
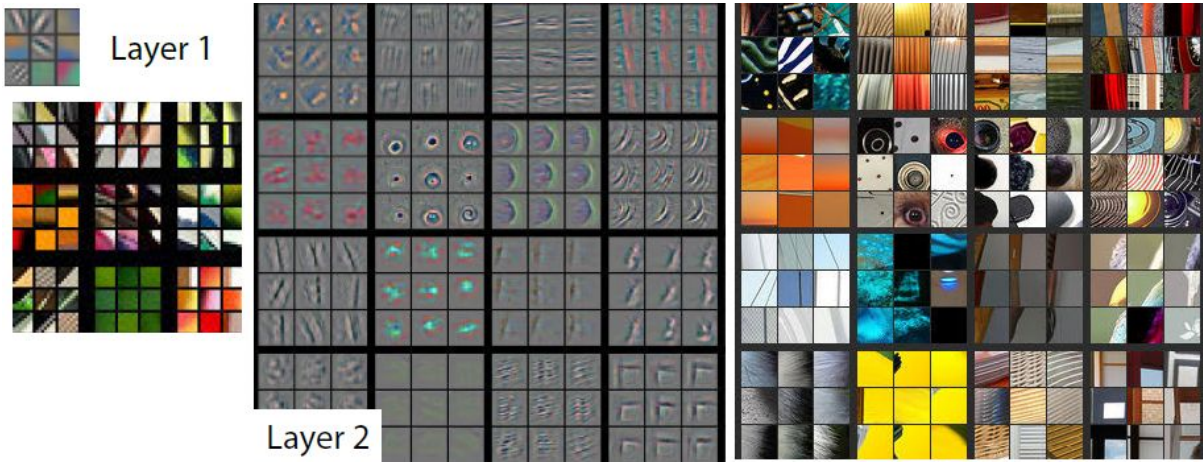
# Importance of machine learning for climate

- **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

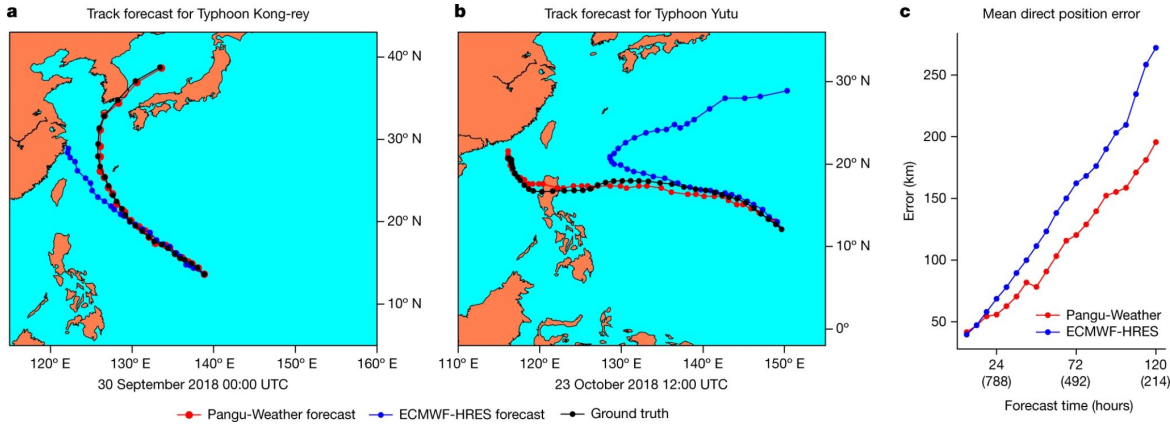
- **Machine Learning's Capability**: Machine Learning algorithms, especially those utilizing deep learning, excel at capturing complex, non-linear relationships. They can learn from massive amounts of data, recognizing intricate patterns and making accurate predictions.




Zeiler, M.D. and Fergus, R., 2014. Visualizing and understanding convolutional networks. In Computer Vision–ECCV 2014: 13th European Conference, Zurich, Switzerland, September 6-12, 2014, Proceedings, Part I 13 (pp. 818-833). Springer International Publishing.

# 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.




Bi, K., Xie, L., Zhang, H. et al. Accurate medium-range global weather forecasting with 3D neural networks. Nature 619, 533–538 (2023). https://doi.org/10.1038/s41586-023-06185-3

# 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.

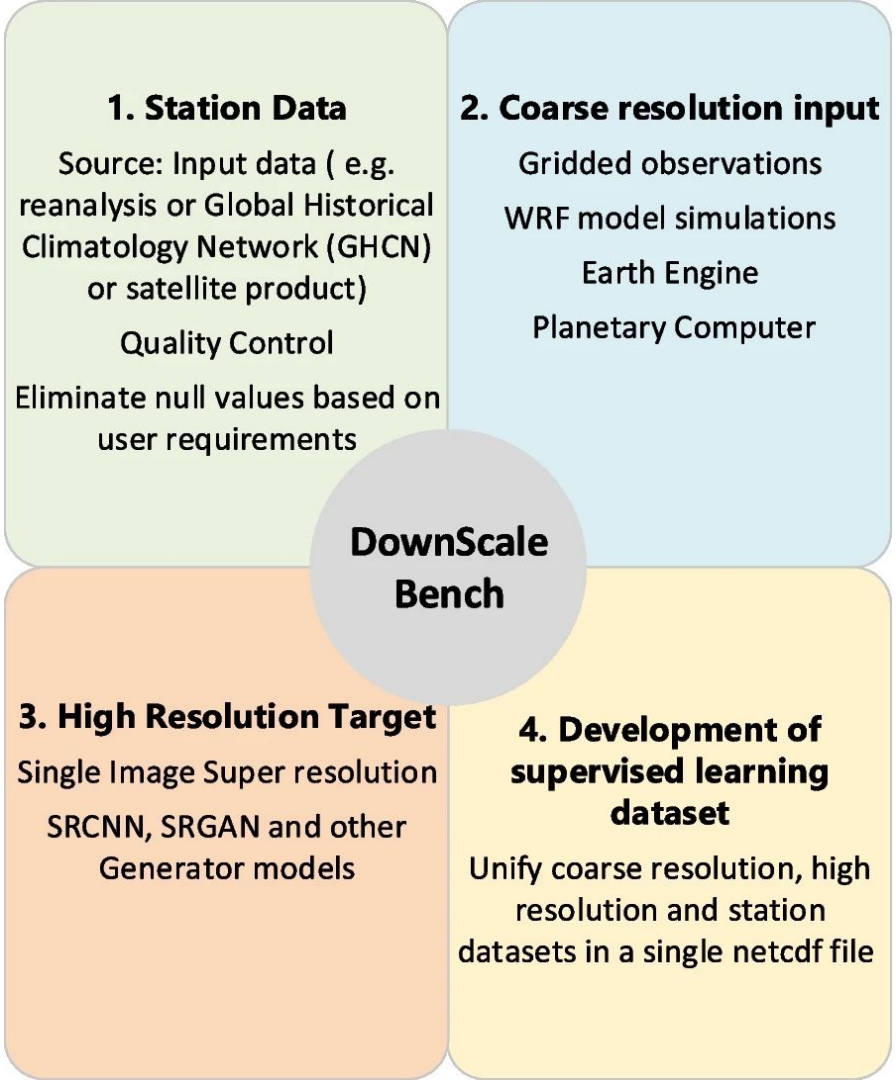
# What do we need for urban digital twins ?

- 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

Singh, M., Acharya, N., Jamshidi, S., Jiao, J., Yang, Z.L., Coudert, M., Baumer, Z. and Niyogi, D., 2023. DownScaleBench for developing and applying a deep learning based urban climate downscaling-first results for high-resolution urban precipitation climatology over Austin, Texas. Computational Urban Science, 3(1), p.22.



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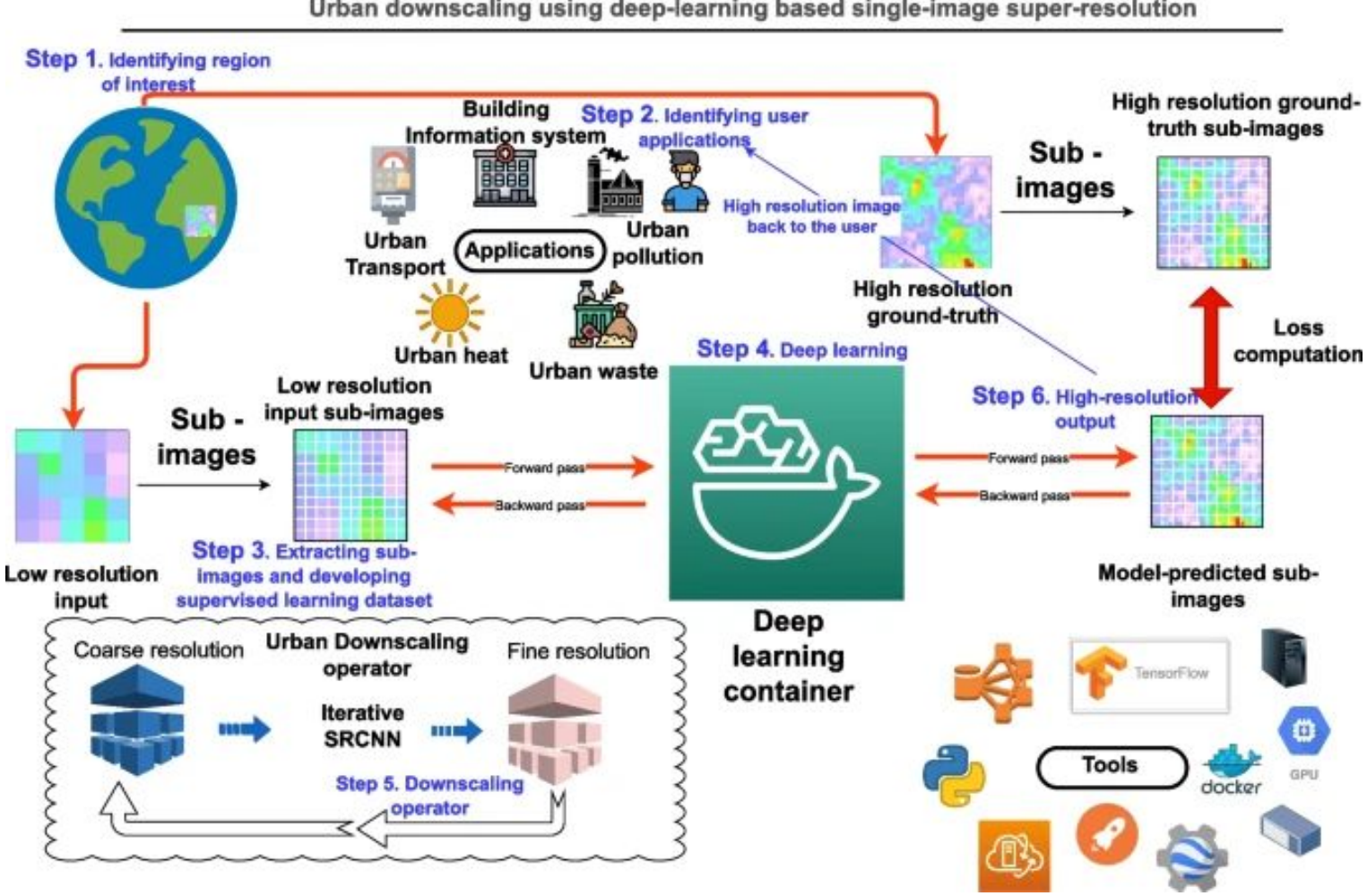
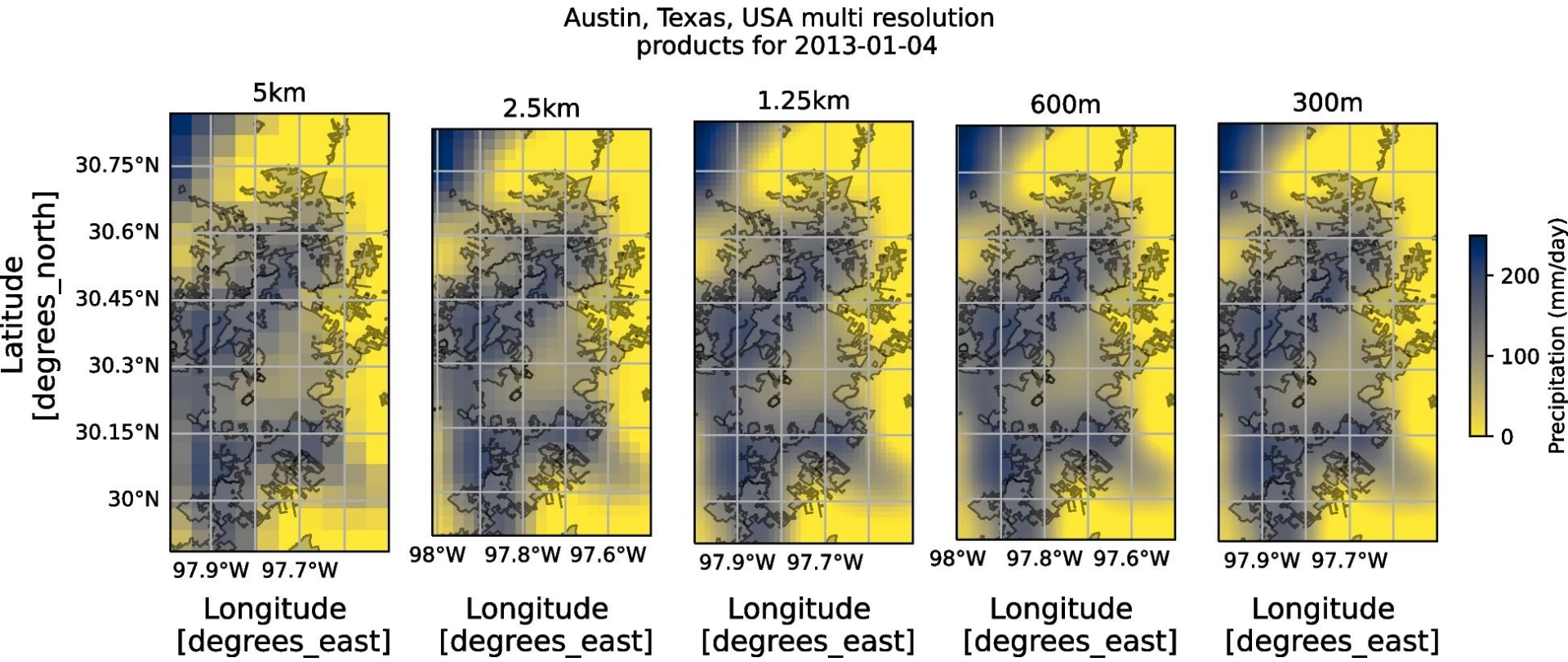
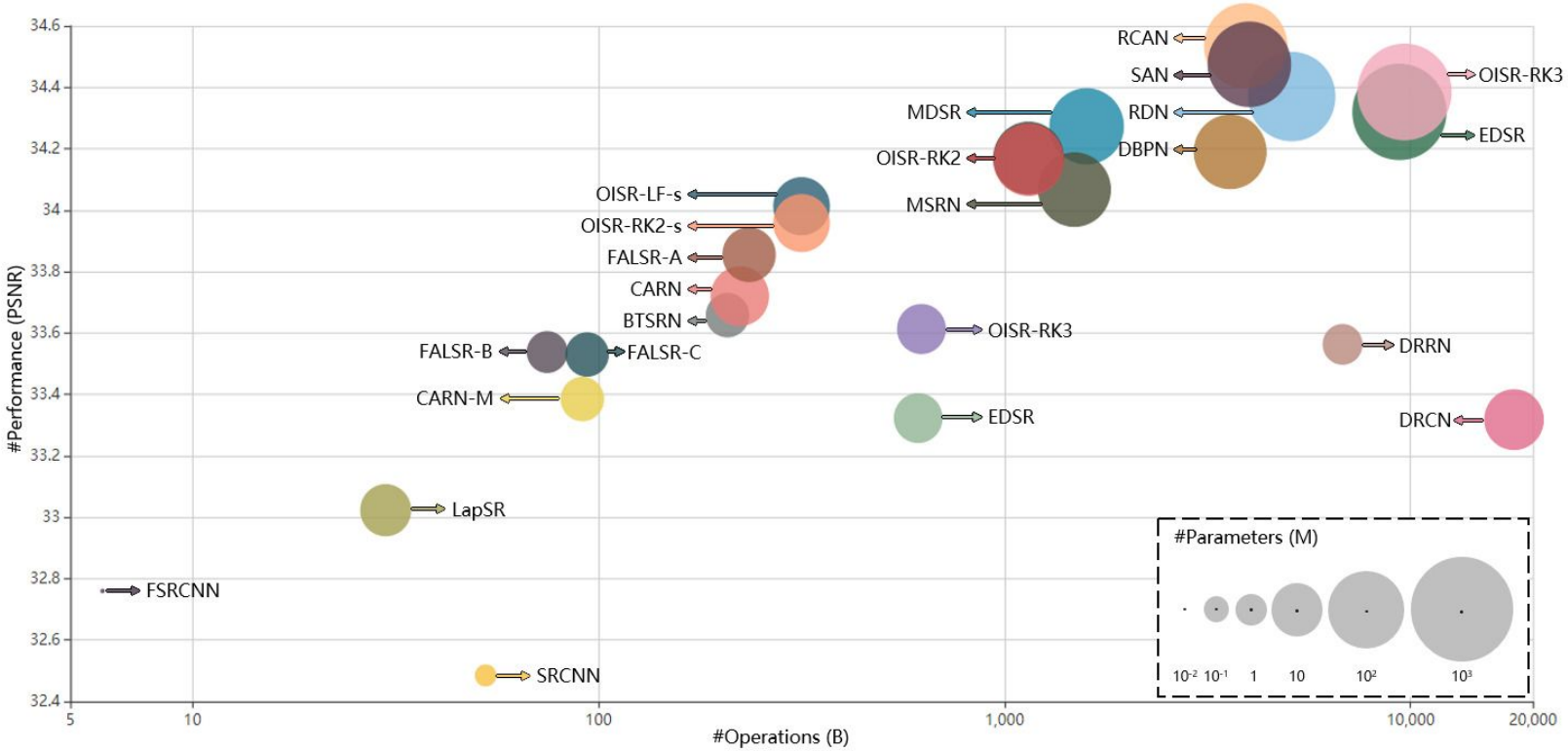





Singh, M., Acharya, N., Jamshidi, S., Jiao, J., Yang, Z.L., Coudert, M., Baumer, Z. and Niyogi, D., 2023. DownScaleBench for developing and applying a deep learning based urban climate downscaling-first results for high-resolution urban precipitation climatology over Austin, Texas. Computational Urban Science, 3(1), p.22.

Next, we need state of the art models to perform super-resolution/downscaling. The solution is being provided by **ClimateDownscaleSuite**

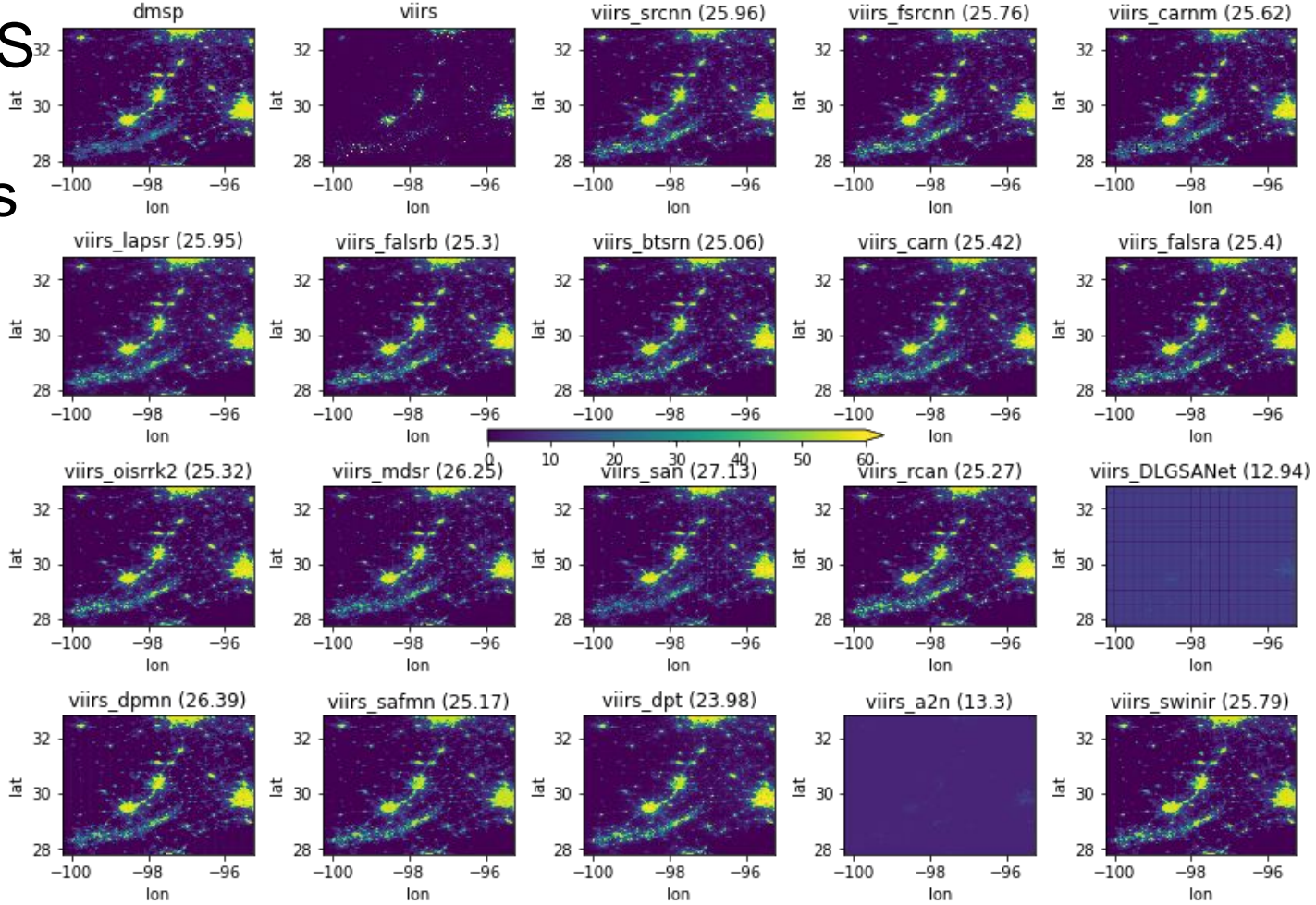
# ClimateDownscaleSuite: Unifying deep learning models for weather and climate downscaling




Singh et al, manuscript in preparation

# ClimateDownscaleSuite

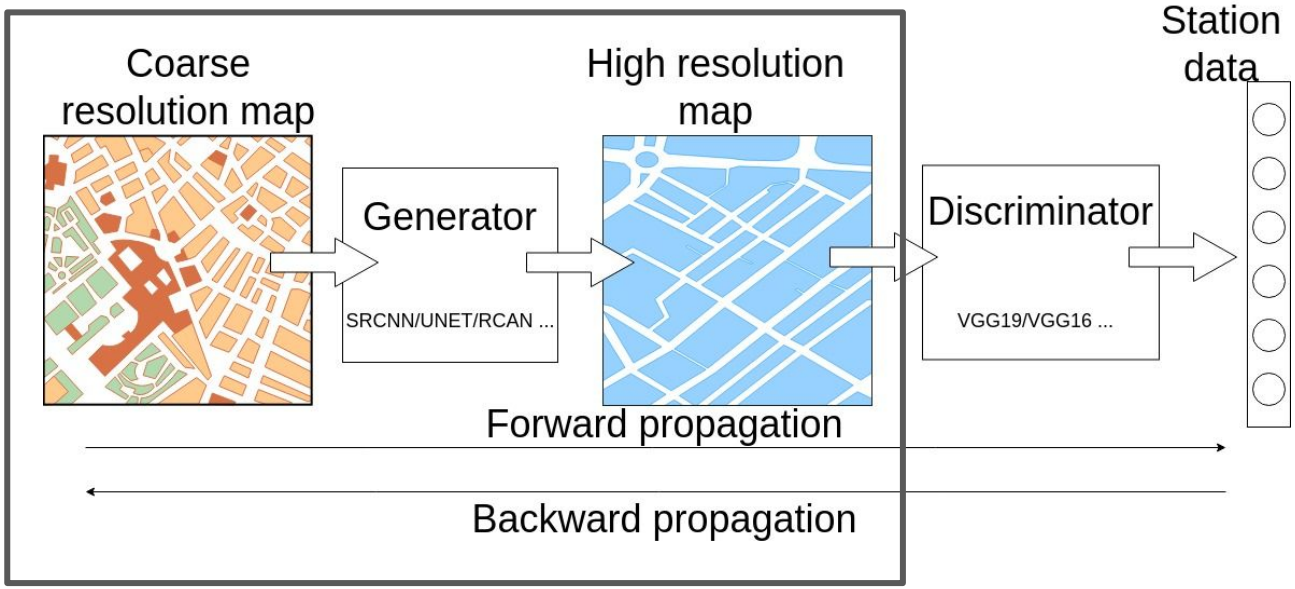
applied to VIIRS to DMSP night time lights data transformation




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