Check for updates

Nature Reviews Earth & Environment | https://doi.org/10.1038/s43017-022-00303-x | Published online: 04 May 2022

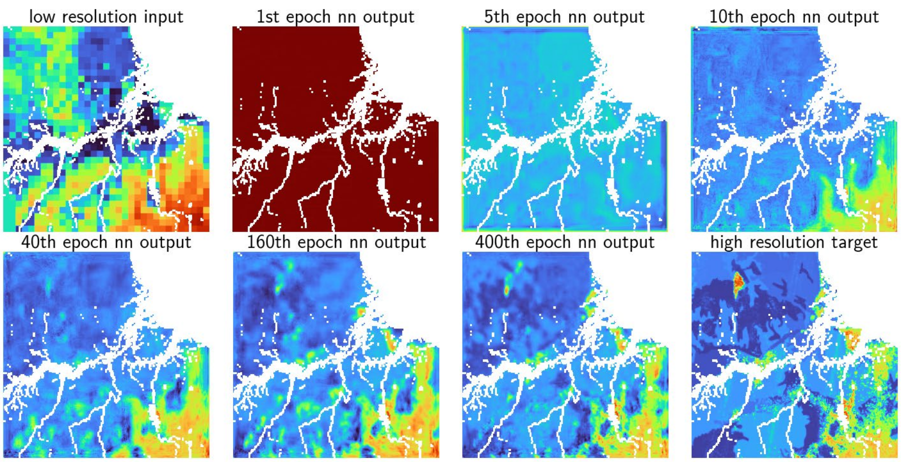
TOOLS OF THE TRADE

A clearer view of Earth's water cycle via neural networks and satellite data

To manage and protect water resources, it is necessary to understand the water cycle. Passive microwave radiometers onboard satellites are used to monitor water resources, like soil moisture. However, microwave sensors, such as radiometers, are too coarse to see small-scale meteorological features, which can affect large-scale phenomena occurring within the water cycle. Other spaceborne instruments produce finer-resolution images, but these instruments are much more sensitive to cloud contamination, limiting their useful coverage.

Neural networks provide an opportunity to build on the global coverage of radiometers by improving their spatial resolution. These networks are a classic methodology in machine learning, taking input and target data pairs and drawing an algorithm connecting the two. To enhance radiometer data from freely available historical environmental datasets acquired from satellite missions such as Aqua, SMAP, and the upcoming SWOT mission, low-resolution images are fed into a very deep neural network. The neural net starts out untrained, taking the input data and turning it into noise. This noise is compared to the desired high-resolution target, and the machine learning framework updates the prediction algorithm based on the comparison. This loop of prediction and refinement is performed many times until the now trained network accurately produces high-resolution images from the original low-resolution satellite radiometer data. These refined images can then be used to better track changes in the water cycle.

Although the mechanics of neural networks have been around for decades, their application in water science has become more popular with the advent of open-source software and inexpensive high-powered computing. Enhanced resolution microwave radiometer products are increasingly vital to the geoscience community. For example, higher-resolution soil moisture data (like that in the graphic showing a neural network training process at the mouth of the Amazon River) will improve numerical weather prediction, drought analysis, crop yield planning, and flood forecasting. A detailed, clearer view of the water cycle resulting from applying neural networks will support more sustainable management of water resources.



Data from Kim, S. et al. 2016. SMAP L3 Radar Global Daily 3 km EASE-Grid Soil Moisture, Version 3. April 13-July 7th, 2015 NSIDC Distributed Active Archive Center https://doi.org/10.5067/IGQNPB6183ZX (2016) and O'Neill, P.E. et al. 2021. SMAP L3 Radiometer Global Daily 36 km EASE-Grid Soil Moisture, Version 8. April 13-July 7th, 2015. NSIDC Distributed Active Archive Center https://doi.org/10.5067/OMHVSRGFX38O (2021) accessed March 26, 2022.

Albert Larson

Department of Civil and Environmental Engineering, University of Rhode Island, Kingston, RI, USA.

e-mail: albertl@uri.edu

Competing interests
The author declares no competing interests.