Application of deep learning techniques to precipitation guidance in short-term weather predictions

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Introduction

Although numerical weather prediction models are useful methods for predicting rainfall in the short-term, it is difficult to avoid errors when making these predictions. The application of deep learning techniques, which have had remarkable results in processing big data, can effectively correct the outputs of numerical weather prediction models.

Objectives

In this study, we developed a method using deep learning techniques to correct numerical weather prediction model outputs. Using this method, the output rainfall amounts can be used as precipitation guidance.

Methods

We used a Convolutional Neural Network (CNN) as the deep learning model. The data augmentation and data selection (rejection of no rainfall data) were applied. We assumed a regression problem and the sum of squared errors was adopted as the loss function in the CNN. The rainfall amount should not be zero and should be a continuous value, so the Rectified Linear Unit (ReLU) was adopted as the activation function.

The input data for the deep learning model was acquired from numerical weather prediction models between August 1-to 31 2001 in the Keihanshin region of Japan. As input variable, vertical near-ground wind speeds was selected. For the numerical weather prediction model, we used the Heavy Rainfall Event by a CReSiBUC, which consists of Cloud resolving atmospheric model CReSS and a land surface model SiBUC. CReSiBUC considers detailed information regarding urban activity.

For the training data we used observed rainfall amounts based on Radar/Raingauge-Analyzed Precipitation data provide by the Japan Meteorological Agency. The observed data were interpolated, using the nearest neighbor method into the same meshes simultaneously with the prediction results.

Results and discussions

The two-dimensional rainfall distributions before and after being corrected by the deep learning method were compared with the observed data from the Radar Raingauge Analyzed Precipitation. The accuracy was improved by the introduction of the deep learning technique at 01:00JST (Japan Standard Time) on August 21, 2001 during a typhoon rainfall event. We found that the introduction of the deep learning technique effectively improved the accuracy of a precipitation event at a large spatial scale during a typhoon. Conversely, the deep learning technique did not improve the accuracy at 14:00JST on August 6, 2001 during a localized heavy rainfall event. Therefore, errors in the position of the precipitation area cannot be completely corrected in the case of rainfall events at small spatial scales.

Summary

In this study, we have used deep learning techniques to develop a method of precipitation guidance to correct numerical weather prediction model outputs. When comparing these results with observed rainfall distribution, the method is effective for large spatial scale precipitation events such as typhoons. However, errors in the position of the area of precipitation cannot be corrected completely in the case of precipitation events at small spatial scales and this needs to be investigated in future research.

Keywords: Short-term weather prediction, Machine learning, Deep learning, Numerical prediction model, Precipitation guidance