Study on Doppler Weather Radar QC Using U-net Model

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Introduction

The distributed photovoltaic power generation devices are not well equipped for meteorological observation, so that the grid-covered meteorological remote sensing data, such as observations from weather radars and satellites, are needed to supplement the weather conditions around them. Compared with the meteorological NWP model, Doppler weather radar has the characteristics of high spatial and temporal resolution as well as three-dimensional space detection, etc., which has been widely studied and applied in short-term precipitation forecast. The quality of short-term precipitation forecast is highly dependent on the quality of input radar data. At present, about 50% of Doppler radars in China are still single-polarization(single-pol) radars, which can not remove the clutter such as clear sky echoes effectively based on fuzzy logic, the traditional radar quality control(QC) algorithm, resulting in a high false alarm rate of forecasts, and therefore affecting the accuracy of solar ultra-short-term forecasts. There have been studies using neural network methods for radar QC, It's proved that this method can recognize clutter[1, 2].

Objectives

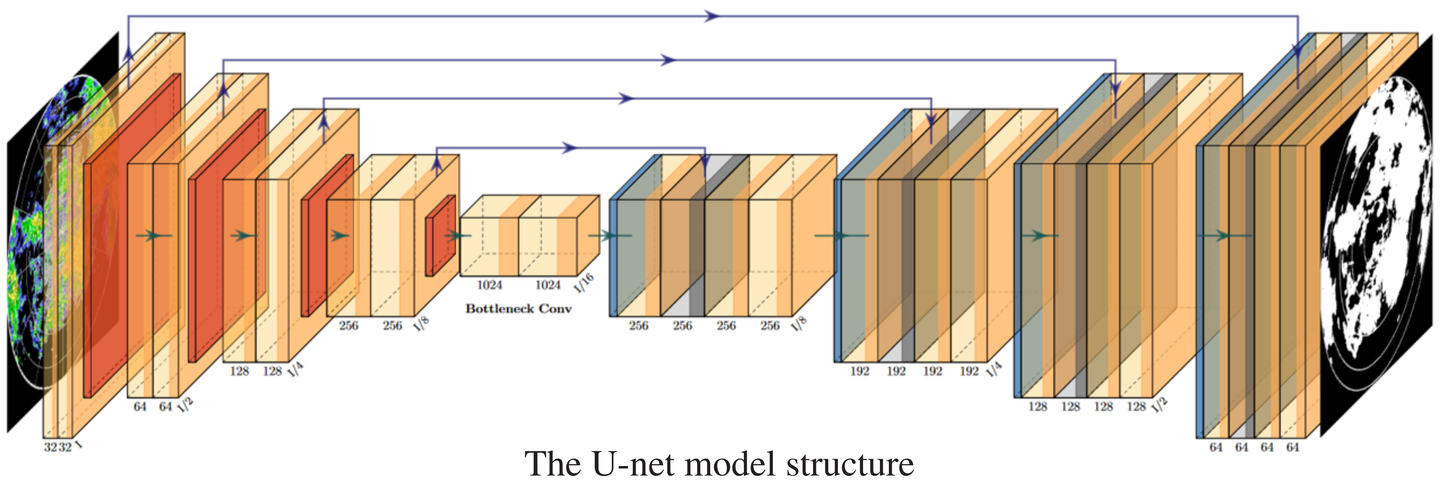
This study proposes to use U-net in deep learning for radar echo quality control, thereby improving the quality of 0-2 hour short-term precipitation forecasts and providing high-quality input data for solar ultra-short-term prediction model. This study uses data from 9 radar stations in Jiangsu, China.

Principal Findings

(1) The weighted mean Intersection over Union(wIoU) of all stations is above 80%, which means that the model has good recognition ability for both meteorological and non-meteorological echoes.
(2) The Critical Success Index(CSI) score has improved from 25.56% to 31.22% for 0-2 hour precipitation forecast, with a 5.57% increase and the false alarm rate decreased by 11.3% from 68.2% to 56.9% after using this radar QC data.Statistics from October 2021 to August 2022.

Data and Method

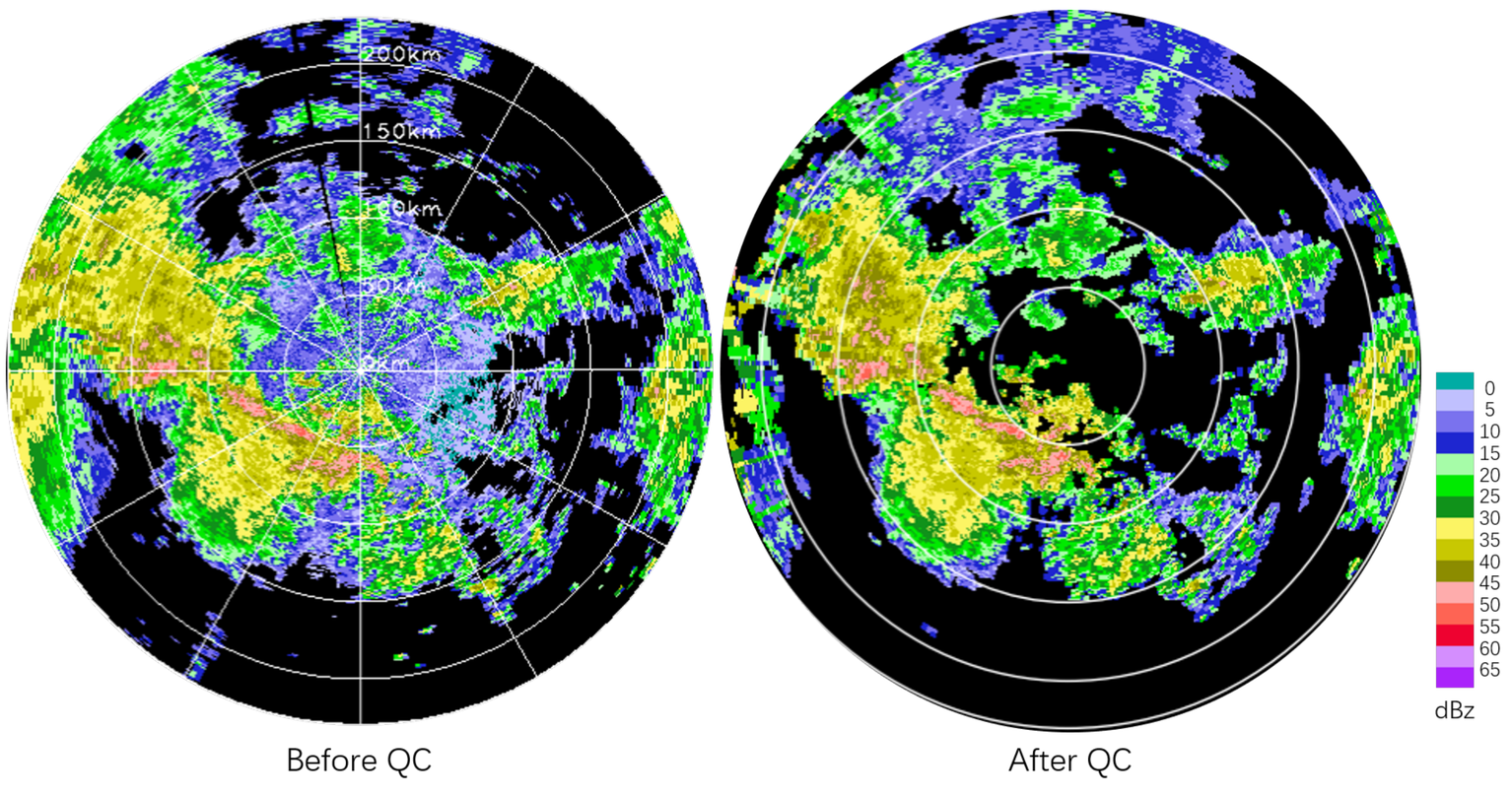
The data set in this study consists of radar reflectivity image as input and echo marker mask as target image.The input radar reflectivity images were obtained from nine S-band single polarization radars in Jiangsu Province.The target was manually marked by radar experts.The target image is an image composed of values 0 and 1, and 1 is the meteorological reflectivity echo.The data set contains about 100,000 samples.
This study combines the U-net[3] model and the transfer learning method to achieve the quality control of Doppler weather radar in a situation where only radar reflectivity images are used. In addition, two weighted loss functions, BCE and Dice[4], are used in the model. Optical flow method is then used for 0-2 hour short-term precipitation forecast on the quality-controlled radar data.



The U-net model structure

Conclusions

The model with U-net network structure performs quality control of radar echoes effectively while using radar reflectivity images only. It is able to identify meteorological echoes and remove non-meteorological echoes with an wIOU of more than 80%. The data can improve the quality of 0-2 hour short-range precipitation forecasts, CSI score has improved from 25.56% to 31.22%. It can provide high-quality input for solar ultra-short-term forecast model.



Before QC

After QC

Loss Function

We used two weighted loss functions, BCE and Dice[4].Radar echoes are usually small in area throughout the detection range, and the complex loss function can provide a more balanced and stable model classification[5].

$$L_{total} = \lambda_1 L_{BCE} + \lambda_2 L_{Dice}$$

$$L_{BCE} = -(y \log(p) + (1-y)\log(1-p))$$

$$L_{Dice} = 1 - \frac{2|X \bigcap Y|}{|X|+|Y|}$$

Future work

This radar QC model based on supervised learning method needs a lot of manual marking work. Based on the quality control results of dual-polarization radar and transfer learning,next step will reduce the manual work and QC models will be established in more single-polarization radar stations.

Contact Information

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