Support Vector Regression (SVR) Based Framework for Wind Field Retrieval with Doppler Weather Radar (DWR)

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Weather radar is a critical tool in meteorology, providing invaluable insights into atmospheric conditions and in detecting precipitation, storm intensity, and movement. Several studies have been conducted using DWR observations to retrieve the local wind field. These winds are vital in transporting mass, momentum, and energy throughout the atmosphere, influencing various meteorological processes. Traditional methods like velocity-azimuth display (VAD) and volume-velocity processing (VVP) assume linearity in wind patterns, introducing potential inaccuracies in the case of non-uniform flow [1], [2]. Furthermore, studies suggest that in traditional VVP, where multivariate regression is used to estimate the wind field coefficients, this leads to an ill-conditioned matrix and poses practical limitations in estimating the wind fields for small analysis volume. Studies indicate that the application of machine learning techniques for estimating wind fields from single Doppler radar data eliminates the constraint of linearity, resulting in more accurate predictions of the wind field [3]. The present study aims to leverage machine learning (ML) techniques that can potentially overcome the challenges posed by ill-conditioned matrices and the linearity assumption in wind field retrievals. These models can adapt to complex wind patterns and learn from radar radial velocity data, leading to more realistic and accurate wind field representations. This study explores a support vector regression (SVR) based framework for retrieving wind fields, incorporating the k-means clustering algorithm to consider the analysis volume. The proposed methodology is shown in Fig. 1. In a simulated experiment, the SVR method effectively captured a uniform horizontal wind field, with a notably strong correlation between simulated and predicted winds. The comparison of retrieved winds at different altitudes with ERA5 winds reveals that the RMSE increases with altitude. The RMSE at lower altitudes is found to be about 5–6 m/s up to 6 km and further increases with altitude. Ongoing efforts involve model fine-tuning, comprehensive retrievals and validation for DWR data, contributing valuable insights to improve our understanding of extreme meteorological events and enhance forecasting accuracy.

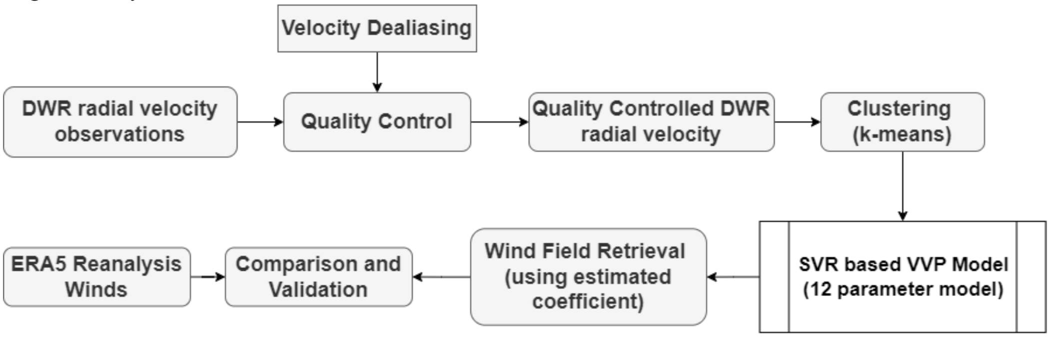

Fig 1: Flow chart representation of the proposed algorithm.

Keywords: Doppler weather radar, wind field, machine learning, support vector machine

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