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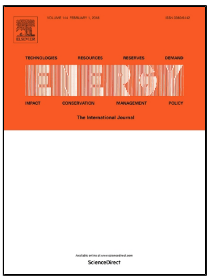

Wind Field Reconstruction using Dimension-reduction of CFD data with Experimental Validation

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Wind Field Reconstruction using Dimension-reduction of CFD data with Experimental Validation

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Abstract: Short-term wind forecasting is important in updating wind electricity trading strategies, facility protection and more effective operation control. Physical based models, particularly those using computational fluid dynamics (CFD), are able to provide ever more detailed wind speed data. However, such methods involve handling a huge amount of CFD data, which is prohibitively time consuming for a short-term wind forecast in real situations. To solve this problem, Singular Value Decomposition (SVD) and Principal Component Analysis (PCA) algorithms are applied in this study to reduce the dimensions of wind speed data and the proposed method is applied to reconstruct the wind field. Wind fields have successfully been reconstructed with good accuracy for the wind direction angles ranging from 0° to 90°. This method is validated by experimental data from a wind tunnel experiment. The accuracy of the proposed reconstruction algorithm increases with the sampling rate of the measurement and the locations of the sensors do not significantly affect the accuracy of the results. Gaussian noise introduced into the input signal does not significantly deteriorate the reconstruction quality. Results show that the proposed method can adequately be used to reconstruct the wind field for the models tested with a high degree of confidence.

Keywords: Wind field reconstruction, wind speed, wind direction, CFD, dimension-reduction, SVD.

Nomenclature	
μ	Learning rate for basis matrix
A	Location-based matrix
B	Co-efficient vector
b	Co-efficient
D	Factorization error
D_E	Euclidean distance
H	Weight matrix
h	Element of the weight matrix
N	Normal distribution function
n	Number of data points
RE	Reconstruction error
S	Matrix containing eigenvalues
V	Wind speed profile (sample) matrix
W	Basis matrix
w	Element of the basis matrix
X	Original wind field (m/s)
X_R	Reconstructed wind filed (m/s)

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