The functionality of evoTurb (referred to the main script of the codes) is briefly introduced as follows.

1. *TurbConfig.* Import the configuration file.

2. *Execute3DSim.* Call TurbSim or MTG to generate m 3D wind fields with different random seeds and save these wind fields for later use. If the same wind fields already exist, this step will be skipped.

3. *Import3DTurb.* Import the generated 3D wind fields.

4. *Generate4DTurb.* Compute the CFC of the 3D wind fields. Compute the longitudinal coherence matrices using a wind evolution model and the corresponding Cholesky factors. Compute the CFC of the 4D wind field. Apply iFFT to the CFC of the 4D wind field.

5. *Export4DTurb.* Export the 4D wind field as binary files.

The wind evolution models supported by evoTurb are briefly introduced in Appendix B.

In fact, the Mann model additionally contains the spatial coherence of v at different locations, the spatial coherence of w components at different locations, and the coherence between the u and w components at the same position, which theoretically should also be considered in the 4D wind field simulation. de Maré and Mann (2016) and Bos (2017) have proposed methods to extend the Mann model to the spatial–temporal tensor, from which the longitudinal coherence of all velocity components can be derived. However, the model proposed by de Maré and Mann (2016) has not yet been validated with measurements. And Bos's approach (Bos, 2017) requires a formula of the wavenumber-dependent eddy lifetimes, which still need to be investigated with experiments or high-fidelity CFD simulations. Because the longitudinal coherence of the v and w component is less important for LAC compared to that of the u component (Schlipf et al., 2013; Held and Mann, 2019), we put our emphasis only on the u component in this study. The effects of neglecting the longitudinal coherence of the v component and the rationality of assuming the identical longitudinal coherence for the u and w components remain to be investigated.

2.5 Validation of evoTurb

The validation of evoTurb mainly focuses on two aspects: whether the longitudinal coherence is correctly simulated and whether other wind field properties generated by TurbSim and MTG are not affected by evoTurb.

The validation is done by two examples coupling with TurbSim and MTG, respectively. The relevant parameters of the 4D wind field generation are summarized in Table 1. The Mann model parameters are defined according to Mann (1994). For simplicity, the wind evolution model of Simley and Pao (2015) (see Table B1) is applied with user-defined parameters instead of its parameterization model, and the parameters are chosen based on Chen et al. (2021). For the validation of coherence and spectra, we consider the spectrum calculated from one realization (one simulated time series) as one sample and compute the ensemble average of 16 samples generated with different random seeds. It is worth mentioning that the averaged coherence is calculated by dividing the averaged cross-spectrum by the averaged auto-spectra. The auto-spectra and cross-spectra are estimated using the Bartlett's averaged periodogram method (Bartlett, 1948) with rectangular windows (size of 1024 data points).

Table 1. The wind field parameters for the validation. $\alpha\varepsilon^{2/3}$, l, and Γ are the Mann model parameters. I_{ref} and L_u are parameters of the IEC Kaimal model (turbulence class A). And the rest are the common parameters of both models. The hub height is considered 90 m.

Parameters		Values	Notations
$\alpha\varepsilon^{2/3}$	$[\mathrm{m\,s^{-2}}]$	0.11	A measure of the energy dissipation
l	[m]	61	Length scale related to eddy size
Γ	[–]	3.2	Anisotropy due to shear
I_{ref}	[–]	0.16	Reference turbulence intensity
L_u	[m]	340.2	Integral length scale of the u component
V_{hub}	$[\mathrm{m\,s^{-1}}]$	16	Mean wind speed at hub height
a	[–]	2	Wind evolution decay parameter
b	[–]	0	Wind evolution offset parameter

To validate the coherence, Fig. 3 compares the theoretical and simulated coherence between different horizontal separations in the two 4D wind fields. The good agreement between the theoretical and simulated longitudinal coherence of $\Delta x = 50\,\mathrm{m}$ and $\Delta x = 100\,\mathrm{m}$, respectively, proves that evoTurb can correctly model the user-defined longitudinal coherence in 4D wind fields. The fact that the lateral–vertical coherence of $\Delta y = 20\,\mathrm{m}$ is consistent with its theoretical curve confirms that the original turbulence characteristics of both tools are not changed by evoTurb. The good match between the theoretical and simulated 3D coherence of $\Delta x = 50\,\mathrm{m}$ and $\Delta y = 20\,\mathrm{m}$ validates that the longitudinal coherence and the lateral–vertical coherence are correctly combined in evoTurb.

As presented in Sect. 2.4, evoTurb generates a 4D wind field by constraining independent 3D wind fields with the user-defined longitudinal coherence. This process is visualized in Fig. 4 by the example of MTG. Figure 4a–c show three independent 3D wind fields generated with MTG. Obviously, there is no coherence between them. These three wind fields are fed in evoTurb, specifically as the vertical planes at $x = 0\,\mathrm{m}$, $x = 50\,\mathrm{m}$, and $x = 100\,\mathrm{m}$, respectively, in this example. It can be observed in Fig. 4d–f that after applying the longitudinal coherence, the three wind fields become coherent, especially the large eddy structures that correspond to the low-frequency components. More specifically, Fig. 4a and d are identical since the wind field at $x = 0\,\mathrm{m}$ is inherently regarded as the reference wind field in the constraining

Please note the remarks at the end of the manuscript.