Best Practice Guide

Setting Up the Forest Canopy Model in WindSim

Webinar Reference Document | 24 March 2026

Introduction

WindSim's Forest Canopy Model enables more physically accurate CFD simulations at sites where the wind flow is significantly influenced by forest cover. By representing the forest as a porous medium, WindSim introduces additional drag and turbulence source terms directly into the governing flow equations, capturing the deceleration and turbulence enhancement caused by the canopy. This guide explains the model physics, the required GWS file setup, key parameters, and the best practices for reliable results.

1. Model Physics — How WindSim Represents a Forest

WindSim implements the forest using a porous media approach. The forest canopy is treated as a distributed resistance that modifies the wind field within and above the canopy layer. This is achieved by adding source terms to the Navier-Stokes momentum equation and to the k-epsilon turbulence equations.

Equation	Effect of Forest Source Terms
Momentum equation	Two drag terms are added: a viscous resistance term (proportional to velocity) and an inertial resistance term (proportional to velocity squared). At typical wind speeds, the inertial term dominates. C1 is set to zero; C2 (inertial coefficient) is the controlling parameter.
Turbulence (k) equation	An additional turbulence production source term is introduced, representing the mechanical turbulence generated as air flows through the canopy elements (branches, leaves).
Turbulence (epsilon) equation	A corresponding dissipation source term is added. Enabling Forest Turbulence Sources (True) activates both k and epsilon source terms for improved TI accuracy.

> *Key insight: C2 is the most important parameter in the forest model. It controls the magnitude of the canopy drag force and directly affects the simulated wind speed deficit and vertical profile within and above the forest.*

2. Workflow Overview

Setting up a forest simulation in WindSim requires two distinct stages: generating a correctly structured GWS file and then configuring the forest model parameters within WindSim.

Stage 1: GWS File Preparation (Global Mapper)	Stage 2: Forest Model Setup (WindSim)
• Load elevation data for the full simulation domain • Generate background roughness layer for the full domain (e.g. forest = 0.6)	• Load the GWS file and verify: check the Forest tab — forest zone should appear in a distinct colour from the background • Set Roughness Height to match the refinement area forest roughness value • Set Forest Height (average canopy height)

Stage 1: GWS File Preparation (Global Mapper)	Stage 2: Forest Model Setup (WindSim)
• Generate a separate forest roughness layer for the refinement area only, with a slightly higher value (e.g. 0.61) • Combine layers: place refinement roughness layer on top of background layer • Set projection to UTM and export as .gws file	• Calculate and enter C2 using the WindSim Excel tools • Enable Forest Turbulence Sources if TI accuracy is required; switch to Standard k-epsilon • Re-run the Terrain module, then run CFD simulation

> *Note: The GWS file preparation for forest simulations must currently be done in Global Mapper. WindSim Accelerator does not yet support the dual-roughness-layer workflow required for the forest model.*

3. GWS File Setup for the Forest Model

The GWS file must contain two roughness layers to enable WindSim to distinguish the forest zone from the surrounding terrain. The logic is straightforward: WindSim reads the roughness value in the refinement area and uses it to locate and apply the forest model boundary.

Layer	Coverage	Roughness Value
Background roughness	Full simulation domain	Standard land cover values (e.g. 0.6 for forest areas)
Forest roughness (refinement)	Refinement area only	Marginally higher than background (e.g. 0.61). This offset allows WindSim to uniquely identify the forest zone during terrain processing.
Combined layer (exported)	Full domain, refinement on top	Export both as a single .gws file. Verify in WindSim: max roughness should equal the refinement forest value (e.g. 0.61).

> *Tip: After loading the GWS file in WindSim, open the Forest tab. A distinct colour in the refinement area confirms the forest zone has been correctly identified. If the maximum roughness does not match your refinement value, the layer ordering in the export is incorrect.*

4. Forest Model Parameters in WindSim

The following parameters are configured in WindSim's Forest Model settings after the GWS file is loaded. Understanding what each parameter controls is essential for reliable results.

Parameter	Description	Recommended Setting
Roughness Height	The roughness value assigned to the forest in the GWS file (refinement area layer). Must differ slightly from the background roughness to allow WindSim to identify the forest zone.	Set to a value marginally above the background roughness (e.g. background = 0.6, forest = 0.61). This small offset is intentional — it preserves roughness continuity while marking the forest boundary.

Parameter	Description	Recommended Setting
Forest Height	The average canopy height of the forest in the refinement area. Used to define the vertical extent of the porous media zone.	Use the average tree height for the site. If significant variation exists, consider defining multiple forest layers. LiDAR-derived height maps can be used via Global Mapper.
C1 (Viscous Resistance Coefficient)	Represents viscous drag force. At typical wind speeds (high Reynolds number), viscous forces are negligible compared to inertial losses.	Set to 0. This is the standard practice for atmospheric flow simulations.
C2 (Inertial Resistance Coefficient)	The most critical parameter. Represents the inertial drag force of the forest canopy on the airflow. Calculated as: C2 = (LAI / H) × Cd, where LAI = Leaf Area Index, H = forest height, Cd = drag force coefficient.	Use the WindSim Forest Parameters Excel tools (available under Tools menu) to calculate C2. Determine LAI from the species database; Cd typically ranges from 0.1–1.2 (0.2 is widely used in published studies). Iterate after comparing to measurements.
Porosity	Physically represents the ratio of air volume to total forest volume. Not used by the current WindSim GCV solver.	Leave at default or set to 0.99. This value has no effect on results in the current solver.
Forest Turbulence Sources	When enabled (True), adds additional turbulence production terms to the K and epsilon equations, improving TI simulation accuracy in and above the forest canopy.	Set to True when accurate turbulence intensity results are required. Important: when this is enabled, the Standard k-epsilon turbulence model must be used.
Number of Cells in Z (Vertical)	Controls the vertical resolution of the forest zone within the simulation grid.	Use approximately 4–5 cells to span the forest height. For a 20m forest, 4 vertical layers is recommended.

5. Calculating C2 Using WindSim Tools

WindSim provides two Excel-based tools under the Tools menu to guide C2 calculation. These should be used for every project — do not use generic C2 values without site-specific justification.

Tool	Purpose and Method
Tool 1: LAI Database	Provides Leaf Area Index (LAI) values by tree species and country. Filter by species name and/or country to find LAI for your site. Verify the location distance is reasonable before applying the value.
Tool 2: C2 Calculator	Calculates C2 from: C2 = (LAI / H) × Cd where H = forest height and Cd = drag force coefficient. CD ranges from 0.1 to 1.2; use 0.2 as a starting point (most widely used in published studies). Adjust Cd based on tree density and canopy structure.

> *C2 is not a fixed value — it varies with season, species, and canopy density. Treat the initial calculated value as a starting point and adjust iteratively against measured vertical profiles or cross-validation data.*

6. Common Mistakes to Avoid

Mistake	Why It Matters / Correct Approach
Applying the forest model to the entire simulation domain	The forest model modifies the inlet boundary condition. If applied to the full domain, the flow at the boundary is already altered, causing irregular jumps. Apply the forest model to the refinement area only, with a buffer of 7–10 km to allow the flow to fully develop before entering the forest zone.
Assuming forest model always improves AEP accuracy	Based on over 50 forest simulations, enabling the forest model does not automatically improve AEP results. The primary benefit is a more accurate vertical wind profile and turbulence intensity. Run a standard CFD simulation first; only activate the forest model if the vertical profile or cross-validation results are unsatisfactory.
Incorrect or missing dual roughness layer in the GWS file	Without a distinct roughness value in the refinement area, WindSim cannot locate the forest zone. The background and forest roughness values must differ (e.g. 0.6 vs 0.61). Always verify in WindSim's Forest tab after loading the GWS file.
Using an incorrect or assumed C2 value	C2 directly controls the drag force applied by the forest. An incorrect value will produce a poor vertical profile match. Always calculate C2 using the WindSim Excel tools with site-appropriate LAI and Cd values.
Not iterating after the first simulation	The first run with forest model parameters is rarely the final one. Parameters (especially C2 and CD) should be adjusted iteratively to match measured data. Do not accept first-attempt results without validation.
Using a non-standard turbulence model with turbulence sources enabled	When Forest Turbulence Sources is set to True, the Standard k-epsilon turbulence model must be selected. Using other turbulence model variants with this setting active will produce unreliable results.

7. Best Practice Checklist

7.1 GWS File Preparation

- Generate elevation data for the full simulation domain
- Create a background roughness layer for the full domain with standard land cover values
- Create a separate forest roughness layer for the refinement area with a value slightly above the background (e.g. +0.01)
- Stack layers correctly: refinement roughness layer must be positioned on top of the background layer before export
- Set coordinate projection to UTM before exporting the .gws file
- After loading in WindSim, verify the Forest tab shows a distinct zone and the maximum roughness equals the refinement value

7.2 Forest Model Configuration in WindSim

- Run a standard CFD simulation first, without the forest model — use results as baseline

- Set Roughness Height to match the roughness value assigned to the forest in the refinement area
- Set Forest Height to the average canopy height for the site
- Set C1 = 0 (viscous term, not applicable at atmospheric wind speeds)
- Calculate C2 using the WindSim Forest Parameters Excel tools (LAI database + C2 calculator)
- Leave Porosity at default (0.99) — not used by the current GCV solver
- Set Forest Number of Cells in Z to cover the forest height with ~4–5 layers
- Enable Forest Turbulence Sources (True) if turbulence intensity accuracy is required — and switch to Standard k-epsilon
- Re-run the Terrain module after configuring the forest model before running CFD
- Iterate C2 and CD values against measured vertical profiles or cross-validation results

7.3 What Not To Do

✗ Do not apply the forest model to the entire simulation domain — refinement area only
✗ Do not use the same roughness value for background and forest layers in the GWS file
✗ Do not assume the first simulation gives optimal results — iteration is expected
✗ Do not set arbitrarily large roughness values for the forest zone
✗ Do not use non-standard turbulence model variants when Forest Turbulence Sources is enabled

Questions? Contact the WindSim team at support@windsim.com or visit www.windsim.com