AeroField

User Guide and Reference Manual

Architectural wind-flow studies in Rhino 8 and Grasshopper

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About This Guide

This guide explains how to create, inspect, compare, save, and communicate AeroField wind studies. It begins with a single closed building mass and progresses to multi-building sites, advanced display controls, scalar-field interpretation, movie export, and comparison with higher-fidelity CFD workflows.

What AeroField is for

AeroField is an early-design tool for comparative exterior wind studies. It helps architects see approach flow, acceleration around edges and passages, roof deflection, shelter, wake organization, pedestrian-height patterns, section fields, and facade-adjacent exposure. It is designed to make design alternatives easier to discuss before a project moves to specialist analysis.

Product scope

The public Grasshopper interface contains three components:

- **AeroField Study** computes the 3D flow field and displays one of five visualizations;
- **AeroField Advanced Settings** optionally overrides resolution, domain, wind profile, streamline composition, scalar fields, and live viewport labels;
- **AeroField Animation Export** prepares a short animation and saves it in a locally supported format.

The standard workflow needs only one wire into Study. Advanced Settings and Animation Export are optional.

What the results mean

AeroField reports a three-dimensional velocity field and several velocity-derived quantities. Their definitions, units, colors, and interpretation limits are established in chapter 8; use that chapter whenever a result is being read physically rather than simply viewed. Its visualizations are suitable for qualitative and comparative design review when geometry, units, wind inputs, quality, and display ranges are held consistently. Results are not a substitute for project-specific wind-tunnel testing, code-required pedestrian comfort assessment, facade-load analysis, smoke or pollutant dispersion, thermal simulation, or life-safety engineering.

Use the right level of evidence

Do not present AeroField output as certified pedestrian comfort, validated facade pressure, indoor natural ventilation, or a code-compliance result. Use it to form questions, compare options, identify areas that deserve attention, and prepare a clearer brief for specialist analysis.

Conventions used in this guide

Convention	Meaning
BUTTON	A button or command visible in Grasshopper.
Input Name	A component input, output, setting, or named value.
`Value`	Text to enter in a Panel, a filename, or a status value.
H	Characteristic building height used for normalized extents.
Wind From	Meteorological source direction: 0° from north, 90° from east.
Speed-up	Normalized local speed. Its full definition and interpretation appear in section 8.2.

A useful working habit

Leave **Quality** unconnected for the automatic **Standard** field. Use **Preview** only for a deliberately faster, smoother mean-flow check. Confirm the wind direction and inspect physical dimensions when they matter to the interpretation. Select visualization methods after the field is available; method changes reuse the current result. Save the Grasshopper file together with any baked Rhino view, exported movie, Summary, and Diagnostics used in a presentation.

One principle governs the whole workflow

Change one analytical variable at a time. Keep wind, quality, domain, scalar range, and camera policy consistent when comparing design alternatives.

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QUICK GUIDE

From a closed Rhino mass to a readable wind study, a baked view, and a movie with the fewest possible wires.

1

Ten-Minute Quick Start

This chapter creates a complete wind study from one closed Rhino mass. The standard workflow uses one Grasshopper component and one geometry wire.

1.1 What you need

Before opening Grasshopper, confirm that Rhino 8 is running, AeroField is installed, and the building is represented by at least one closed solid or closed mesh. A simple box is ideal for the first run.

The shortest possible workflow

Connect a Geometry parameter containing one closed building mass to **AeroField Study.Buildings**. AeroField starts automatically. No Run toggle is required.

1.2 Create the first building

Make a test mass in Rhino

1. Start a new Rhino model using meters, feet, millimeters, or inches.
2. Draw a closed box. For an architectural-scale test, use approximately $10 \times 10 \times 10$ meters, or the equivalent in the chosen document units.
3. Select the object and confirm that Rhino identifies it as a closed polysurface or closed mesh.
4. Save the Rhino file.

AeroField reads Rhino document units and converts lengths to physical meters. A one-unit cube in a meter document is one meter high; a one-unit cube in an inch document is one inch high. The first study starts without requiring a dimension check. Summary and Diagnostics report the interpreted dimensions when physical scale matters to the analysis.

1.3 Place the Study component

Open Grasshopper and find **AeroField > Wind > AeroField Study**. Place it on the canvas. The streamlined component has six inputs:

1. **Buildings**
2. **Wind Speed m/s**
3. **Wind From degrees**
4. **Analysis Height m**
5. **Quality**
6. **Advanced Settings**

Only **Buildings** is required. The other inputs have useful defaults; **Advanced Settings** is optional.

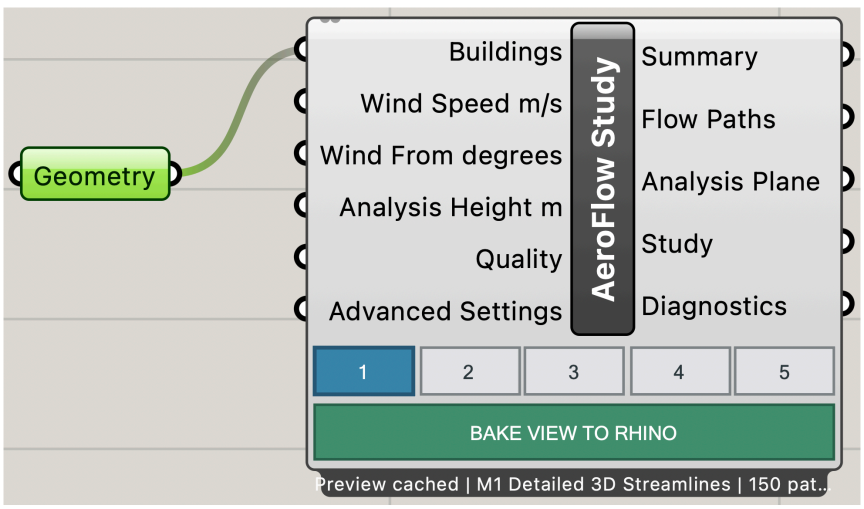


Figure 1.1: The basic Grasshopper connection. A Geometry parameter is wired directly to the Study component's **Buildings** input. The Study updates automatically, and the five numbered buttons change the displayed result without recalculating the wind field.

1.4 Connect the building

Place a Geometry parameter, reference the Rhino box, and connect it to **Buildings**. The component begins preparing and computing automatically. The footer changes as work progresses. A previous valid result remains visible while a new input is being processed.

Adding more than one building

Connect every significant building to the same Geometry parameter as a list. Leave **Quality** unconnected for the automatic **Standard** field. AeroField treats the objects as one site, preserves every occupied building, and chooses the finest practical site grid within the configured limits. Summary reports the achieved resolution and any bounded adaptation. Use **Preview** only for a deliberately faster overall-flow check; its smoother, shorter field development can suppress fine wake structure.

Default values are:

Input	Default	Meaning
Wind Speed m/s	10	Reference incoming speed.
Wind From degrees	0	Wind arrives from north and travels south.
Analysis Height m	1.5	Pedestrian or section height above ground.
Quality	Standard	Normal developed field; connect Preview only for a faster, smoother check.
Advanced Settings	empty	Use the quality preset without overrides.

1.5 See the result in Rhino

The first numbered button, **1**, is selected by default. It shows detailed 3D streamlines. In the normal Standard field, calculated approach and bypass paths can bend or gently meander; they separate around the building, accelerate where the available passage narrows, rise over the roof, and reorganize downstream. A streamline is a directional curve through the stored velocity field, not a measured smoke trail or a flow-rate indicator; see section 8.4.

Every ordinary Method 1 streamline is one continuous integration from the calculated inlet boundary through the site and downstream field. AeroField does not append remote segments, stitch curve pieces together, or create an artificial upstream source plane. Wake-focused paths may begin inside the calculated wake to make local recirculation readable. Upstream Approach H is retained for compatibility with older definitions and is ignored; use Upwind Domain H when the physical inlet region needs more calculated space.

Standard applies a small, reproducible cross-flow variation whose default inlet magnitude is 3 percent of the local incoming speed. The variation is balanced laterally and vertically, preserving the specified mean direction and avoiding a persistent sideways bias. It can make individual calculated paths less perfectly uniform without adding decorative display noise. Preview omits this evolving variation and normally appears smoother.

A sensible cube result

From above, a centered cube under cardinal wind should produce a broadly symmetric left/right pattern. From the wind source, paths should divide around both sides and over the roof. Downstream paths may curve and collect around the lower-speed wake, but they should remain finite, distributed, and attached to recognizable incoming paths. A wake is a disturbed downstream region rather than a hard-edged or automatically turbulent volume; see section 8.5.

1.6 Try the five views

Click the numbered buttons along the bottom of Study:

No.	View	Best first use
1	Detailed 3D Streamlines	Overall approach, side/roof deflection, passages, and downstream organization.
2	Wake and Vortex	Wake shape, recirculation clues, and rotational regions behind the building.
3	Pedestrian Wind Map	Normalized speed-up and shelter on a horizontal plane at Analysis Height; see section 8.2.
4	Flow Sections	Horizontal and vertical slices through selected scalar fields.
5	Surface Exposure	Facade-adjacent speed-up, speed, or pressure proxy; see section 8.6.

Changing a numbered view uses the stored 3D result. It does not repeat the expensive field calculation unless a numerical input also changed.

1.7 Read the component color

Grasshopper color is a fast status signal:

- normal or green means the current operation has no warning;
- orange means the component returned a result with a warning or limitation that should be read;
- red means the current operation failed and the message must be corrected.

The normal Preview time budget is not an error and does not require a user action. A multi-building Preview may add one bounded local-wake pass of up to eight seconds when the first pass leaves a substantial building wake weak. If Summary records that either budget was reached, inspect the finite field and move to Standard when wake width, recirculation, or smaller between-building differences matter. Other orange messages should be read before interpreting the result.

2

Your First Cube Study

A cube is the best diagnostic geometry because its scale, symmetry, windward face, roof, side edges, and downstream wake are easy to recognize.

2.1 Set an unmistakable wind direction

Use **Wind From degrees**=`270`. The wind arrives from west and travels east. In Rhino Top view, the approach should come from the left when world X increases to the right.

Table 2.1: Cardinal meteorological directions.

Wind From	Arrives from	Travels toward	World travel vector
0°	North	South	$-Y$
90°	East	West	$-X$
180°	South	North	$+Y$
270°	West	East	$+X$

Wind From is not an arrow heading

A value of 270° does not mean the air travels toward west. It means the source is west, so travel is east. This meteorological convention is used throughout AeroField.

2.2 Choose a useful Rhino camera

Use three quick camera checks:

1. **Top view** checks left/right symmetry and wake direction.
2. **Wind-source elevation** looks directly downstream and checks lateral/vertical distribution.
3. **Perspective view** communicates the relationship between roof, sides, wake, and ground.

For a centered cube, a cardinal wind, and a centered inlet, persistent one-sided bias in Top or wind-source elevation is a reason to inspect geometry, wind direction, viewport projection, and solver status. Small differences in the selected path set can occur, but the underlying field should not imply a systematic diagonal crosswind.

2.3 Understand physical upstream paths

Visualization 1 draws ordinary streamlines as one continuous integration from the calculated inlet boundary through the site and downstream field. It does not append remote segments, stitch curve pieces together, or create an artificial upstream source plane. Wake-focused paths may begin inside the calculated wake to make local recirculation readable. To create a longer incoming region, increase Upwind Domain H and rerun the calculation. The retained Upstream Approach H input exists only for compatibility with older definitions and is ignored by current versions.

2.4 What to inspect around the cube

2.4.1 Windward face

The incoming flow slows and redirects as it approaches the front face. Paths split toward the side edges and roof. A stagnation-like region is expected near the central windward face.

2.4.2 Side edges

Paths crowd and can accelerate as they turn around the side edges. In Visualization 1, warmer colors represent higher speed according to the current velocity range. Compare both sides under a symmetric setup.

2.4.3 Roof edge

Paths rise over the front roof edge and continue above the roof. The exact near-wall shape depends on field resolution and should be interpreted as a comparative pattern rather than a boundary-layer measurement.

2.4.4 Wake

Behind the cube, speed deficit, turning, and possible local reverse flow create a less orderly region. Visualization 2 emphasizes this region. Visualization 1 balances it with approach and bypass paths.

2.5 Choose Preview only when speed matters more than detail

Leave **Quality** unconnected for the automatic `Standard` field used by normal studies. Connect a Panel containing `Preview` only when you need a faster check of geometry, wind direction, broad deflection, or camera composition and can accept smoother approach and wake structure.

Use `Detailed` only after the model and comparison protocol are stable. Detailed can take substantially longer and use much more memory. It is not a repair button for incorrect units or invalid geometry.

2.6 A complete first-study checklist

Before trusting the first image

1. Optionally confirm the cube dimensions and document units when physical interpretation matters.
2. Confirm the geometry is closed and located at the intended ground elevation.
3. Set a cardinal Wind From direction and identify the expected travel direction.
4. Leave **Quality** unconnected for Standard and inspect Top, wind-source elevation, and Perspective views.
5. Read any orange or red message.
6. Use Preview only when a deliberately faster, smoother field is appropriate.
7. Click all five visualization buttons and verify that method changes are quick.
8. Connect Summary and Diagnostics to Panels when recording or troubleshooting the study.

3

Bake, Save, and Share

AeroField can turn the current live view into Rhino objects or a clean Full HD movie. Both actions reuse the existing Study result.

3.1 Bake the current view

Click **BAKE VIEW TO RHINO** on AeroField Study. The button is active after a valid result exists. AeroField creates persistent Rhino objects for the currently selected visualization, including applicable path curves, scalar meshes, contours, and guide lines.

Bake a presentation view

1. Select one of the five visualization buttons.
2. Adjust the Rhino camera and live display options.
3. Click **BAKE VIEW TO RHINO**.
4. In Rhino, turn off Grasshopper preview to inspect the baked objects alone.
5. Organize, render, annotate, or export the baked geometry using normal Rhino tools.

Baked curves are ordinary Rhino curves. Scalar layers are meshes with vertex colors. AeroField attaches descriptive user strings to identify layer roles, scalar fields, units, ranges, and calculated path origins where applicable.

Bake is a snapshot

Baked objects do not update when Grasshopper inputs change. Delete or archive an older bake before creating a replacement so two studies are not confused in the same Rhino view.

3.2 Connect Animation Export

Place **AeroField > Wind > AeroField Animation Export**. Connect:

```
AeroField Study.Study  ->  AeroField Animation Export.Study
```

That is the entire wiring diagram. The movie component begins preparing two, four, or eight Full HD frames while the user continues working. Its footer reports progress and eventually reads `Ready: N frames | 1080p`.

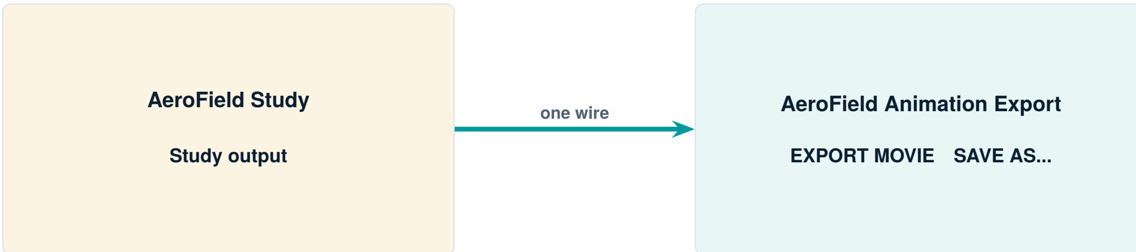


Figure 3.1: Movie export requires only Study to Study. Frames are prepared before either save button is pressed.

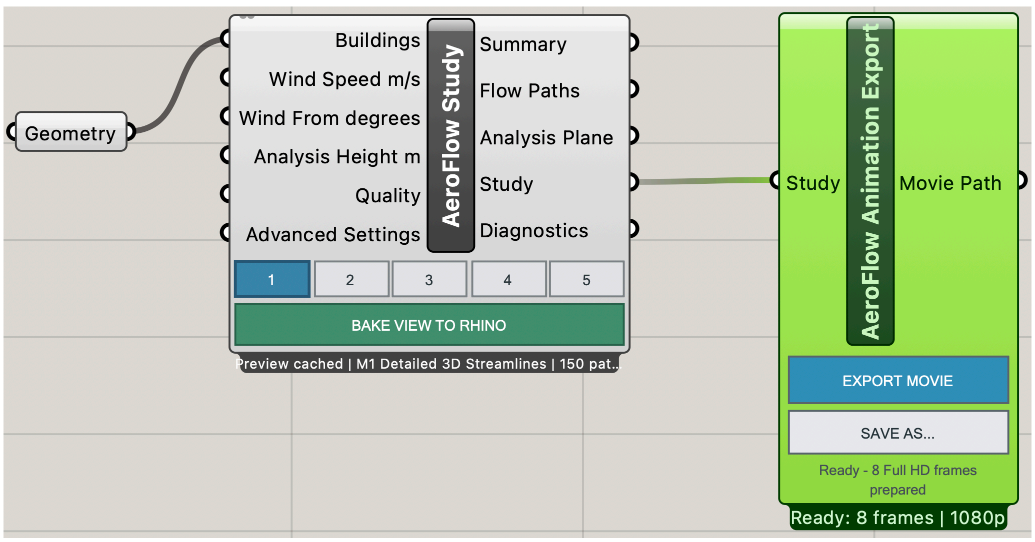


Figure 3.2: A complete movie-export setup in Grasshopper. The Study output is connected to the Animation Export component's **Study** input. When the footer reports that frames are ready, use **EXPORT MOVIE** for the automatic destination or **SAVE AS...** to choose the file name and format.

3.3 Export Movie versus Save As

EXPORT MOVIE writes the default movie format to:

```
Documents/AeroField/Movies/
```

The filename includes a timestamp, and Finder or File Explorer opens to the saved file.

SAVE AS... opens a native save dialog. Its format list is populated from the movie encoders available on the local computer. Depending on the installed `ffmpeg`, choices can include MP4, MOV, WebM, MKV, AVI, animated GIF, and animated PNG.

The **Movie Path** output reports the last successfully generated file. Connect it to a Panel when a visible, copyable path is useful.

3.4 What the movie contains

The compact movie uses moving bright packets over the current fixed flow paths. It is a presentation of motion through the stored field, not a newly calculated time sequence.

Every exported frame is clean:

- no AeroField title or status text;
- no scalar or streamline colorbar;
- no legend ticks or legend axis;
- no Rhino construction grid or world axes;
- a fixed active Rhino camera;
- Full HD dimensions of 1920 by 1080 pixels.

The live viewport can still show labels and color legends for interpretation. Movie output deliberately removes them so titles, captions, and branding can be added in presentation software without baked-in clutter.

3.5 Frame preparation and camera changes

The component first prepares two visibly different packet positions. If capture is fast, it prepares four or eight evenly spaced frames. The output duration remains two seconds; the available frame count determines the frame rate.

Prepared frames are tied to the Study, selected visualization, dimensions, background, and active camera. Moving the camera after preparation creates a new frame identity. Wait for the component to report Ready again before saving when the new camera must be used.

3.6 Quick sharing checklist

Before sharing a bake, image, or movie, record:

- Wind From and wind speed;
- quality and any Advanced Settings connection;
- visualization method;
- scalar field, units, and color range when relevant;
- Analysis Height for pedestrian maps and horizontal sections;
- solver status and any warning;
- a statement that the result is an early-design comparative preview.

GUIDED LEARNING

Build confidence progressively: scale, geometry, wind, quality, visualization, scalar interpretation, and presentation.

4

Units, Scale, and Building Geometry

A plausible wind image begins with correct physical scale and purposeful exterior geometry. AeroField converts Rhino document units to meters before creating the study.

4.1 Physical units

Wind speed and Analysis Height are always expressed in SI units on the component: meters per second and meters. Building geometry can remain in the Rhino document unit system. AeroField applies the document conversion automatically.

Rhino unit	One model unit	Example ten-meter building height
Meters	1 m	10 units
Millimeters	0.001 m	10,000 units
Feet	0.3048 m	approximately 32.808 units
Inches	0.0254 m	approximately 393.701 units

Never compensate for an incorrectly scaled model by changing wind speed, Analysis Height, or domain settings. Correct the Rhino geometry or document units first.

4.2 Interpreted dimensions

The first study does not stop or turn orange because a model is small. AeroField still converts Rhino document units to physical meters and reports the characteristic height, model-to-meter conversion, cell size, and solved domain in Summary and Diagnostics. Inspect those values when the physical meaning of the model matters.

4.3 Preferred geometry

The best inputs are closed exterior masses with clean normals and no duplicated or self-intersecting faces. AeroField accepts Breps, extrusions, SubD-derived meshes, and meshes through Grasshopper's Geometry parameter, but the final object should describe a closed volume.

For early design, include the forms that meaningfully redirect exterior air:

- primary building volumes;

- major podiums and setbacks;
- canopies or screens large enough to occupy several cells;
- nearby buildings that shape approach corridors or shelter;
- terrain only when it materially changes the flow and can be represented cleanly.

Omit facade joints, mullions, handrails, furniture, and details far smaller than the chosen cell size. Tiny geometry can increase preparation cost without producing resolved flow features.

4.4 Open or invalid objects

When preferred geometry preparation cannot establish a reliable closed occupancy, AeroField can use a conservative bounding-box representation and issue a warning. This keeps a study available, but it removes shape detail. A slender or articulated building may become an overly blunt block.

A fallback changes the model

If Diagnostics reports bounding-box occupancy, repair the source geometry before using the result for design comparison. A fallback is useful for diagnosis, not a silent substitute for the intended architecture.

4.5 Ground elevation

AeroField infers ground from the lower prepared building elevation unless **Ground Elevation m** is connected in Advanced Settings. The solved volume begins at ground and does not extend below it. Building and ground surfaces are treated as solid boundaries.

Connect Ground Elevation only when world Z=0 is not the intended ground or when elevated geometry makes inference ambiguous. The value is in physical meters, regardless of Rhino document units.

4.6 Multiple buildings

For a site, connect all significant building masses as one list. AeroField identifies a resolution-driving mass and can adapt the site resolution within its memory budget. Summary reports total, major, and secondary building counts plus the dimension used to set resolution.

When **Quality** is left unconnected, automatic **Standard** treats the connected masses as one site, preserves every occupied building, and selects the finest practical site grid within the configured limits. Summary reports the achieved resolution and any bounded adaptation. Connect **Preview** only for a deliberately faster broad-flow check; its smoother, shorter field development can suppress smaller separated shear layers and fine differences between individual wakes.

Use consistent geometry scope when comparing alternatives. Adding or removing a distant building can change domain extents and cell size, so it should be treated as an analytical change rather than presentation cleanup.

4.7 Geometry checklist

Prepare a reliable site model

1. Duplicate the architectural model for analysis.
2. Join or mesh exterior masses into closed volumes.
3. Remove unresolved detail and interior geometry.
4. Confirm model units and measure a known height.
5. Put all intended buildings into one Grasshopper Geometry parameter.
6. Leave **Quality** unconnected for Standard and inspect warnings, building count, height, and occupancy information.
7. Correct fallbacks before escalating quality.

5

Wind, Domain, and Vertical Profile

AeroField separates the reported wind source direction from the travel vector and uses a height-dependent incoming profile by default.

5.1 Meteorological direction

Wind From degrees specifies where the wind comes from. Values wrap around 360 degrees, so 360° and 0° are equivalent. Oblique values use both world X and Y components; for example, 225° arrives from southwest and travels northeast.

Use a Rhino compass, North arrow, or a simple line in the travel direction when coordinating a site plan. Do not infer direction only from a perspective camera.

5.2 Reference wind speed

Wind Speed m/s defaults to 10 m/s. It must be greater than zero and no more than 100 m/s. This is a reference incoming speed, not necessarily the speed at every elevation.

The default Power Law profile changes incoming speed with height. Near-ground incoming speed is lower; upper-level speed is higher. For the precise Speed-Up ratio and why it uses a same-height incoming reference, see section 8.2.

5.3 Wind profile options

Advanced Settings offers:

- **Power Law**: height-dependent incoming speed; default and recommended for exterior conceptual studies;
- **Uniform**: the same incoming speed at every height; useful for controlled geometric comparisons and diagnostics;
- **Terrain Exponent**: controls vertical shear in Power Law mode;
- **Wind Reference Height m**: optional absolute height at which Wind Speed applies.

When Wind Reference Height is disconnected, the profile is scaled to the characteristic building height. This supports geometrically similar studies at different model scales. Connecting a value switches to an absolute physical reference height.

Conceptual terrain	Exponent	Interpretation
Open coast or water	0.10–0.14	Low vertical shear; unobstructed approach.
Open terrain	0.14–0.20	Fields, low vegetation, sparse obstacles.
Suburban	0.20–0.28	Mixed low-rise development and trees.
Dense urban	0.28–0.40	Stronger vertical shear; use only with project-specific justification.

These are conceptual starting points, not a substitute for a site wind-climate or roughness study.

5.4 Solved domain extents

The 3D field occupies a wind-aligned domain around the prepared buildings. Extents are expressed in characteristic building heights H:

Direction	Standard	Purpose
Upwind Domain	$5.0H$	Solved approach before the buildings; matches Standard's downwind extent. Preview uses $4.5H$ on both sides.
Downwind Domain	$5.0H$	Wake-development space after the buildings.
Side Domain	$1.5H$ each	Lateral clearance beyond the site.
Top Domain	$1.0H$	Clearance above the tallest mass.

Visualization 1 draws ordinary streamlines as direct integrations from the calculated inlet boundary through the site and downstream field. It does not append display-only context or join separate curve pieces. **Upstream Approach H** is retained for compatibility with older definitions and is ignored. **Upwind Domain H** changes the calculated field and therefore reruns the study when a longer physical inlet region is needed.

5.5 When to enlarge the domain

Increase domain extents when boundaries crowd the region of interest, a long wake is analytically important, several buildings fill the default site envelope, or oblique flow leaves insufficient clearance. Every increase can enlarge the 3D grid substantially. Change one extent at a time and inspect total cells.

Increase the calculated Upwind Domain only when the physical inlet region needs more space. Method 1 does not manufacture additional path length beyond the solved field.

6

Quality, Resolution, and Result Status

Quality is a coherent preset that balances spatial resolution, field-development effort, memory, and elapsed time.

6.1 Quality presets

Quality	Target cells across	Typical role	Guidance
Preview	8	Fast broad-flow check	Smooth mean-flow field with short calculation effort.
Standard	24	Normal study	Automatic developed field with balanced low-level incoming variation.
Detailed	32	Intentional refinement	Use after the model and comparison protocol are stable.

"Cells across" refers to the smallest significant dimension that drives resolution. It is more informative than total cells alone because it describes how well a building mass is represented.

Standard is not a perfectly smooth mean picture. Its incoming boundary includes a reproducible cross-flow variation with a default magnitude of 3 percent of the local incoming speed. The variation is balanced across the inlet, so it adds no net lateral or vertical wind. Calculated approach and bypass paths may therefore meander gently while the overall path family retains the requested mean direction and no persistent side bias. This is part of the stored velocity snapshot, not a visual wiggle filter and not a direct turbulence-intensity result. Preview omits this evolving variation and normally appears smoother.

6.2 Why total cells grow quickly

AeroField uses a uniform 3D field. Halving cell size can multiply the number of cells by roughly eight before domain-shape effects. More cells also increase memory, preprocessing, derived-field, and path-sampling cost.

This is why resolution, domain size, and site extent should be managed together. A large site at high target resolution may exceed the configured cell budget even when each building seems simple.

6.3 Advanced resolution controls

Target Resolution accepts 6 through 64 cells across. **Maximum Cells** accepts 30,000 through 2,500,000. **Allow Resolution Relaxation** determines what happens when both cannot be satisfied:

- false: Standard or Detailed stops with a clear resolution/budget error when a requested single-building or explicit-resolution study cannot fit;
- true: Study may reduce actual cells across to fit the budget and reports the tradeoff.

Automatic site adaptation preserves every occupied building and selects the finest practical grid within the selected quality limits. This adaptation is not the same as connecting **Allow Resolution Relaxation**. Read the achieved resolution in Summary before comparing small wake features across alternatives.

Preview is deliberately fail-soft for a valid tall or unusually slender single building. It retains the full building height and top clearance, then uses the finest bounded field that fits its expanded preview allowance. This avoids an arbitrary height cutoff, but it does not make a coarse tower width precise. Use the reported cells across to decide whether the result is suitable for broad flow orientation only or whether Standard, Detailed, a larger budget, or a smaller domain is required.

Keep relaxation off for controlled comparisons unless the reduced resolution is explicitly accepted and recorded. Comparing alternatives at different actual resolution can change wake and derivative-field appearance.

6.4 Result status

Summary and component messages distinguish several outcomes:

Status	Practical interpretation
Converged	The configured stopping conditions were satisfied.
Transient snapshot ready	The requested wake-development interval completed.
Time limit reached	A finite best-available field was returned at the time budget.
Maximum iterations reached	A finite field may exist, but the iteration cap arrived first.
Unstable	Numerical health checks failed; do not use the result as a design conclusion.
Cancelled	The user cancelled the active solve; the last valid result may remain visible.
Bounded site preview	A valid multi-building site or tall/slender single-building Preview was returned at the finest bounded grid that fits its preview allowance; inspect broad flow patterns and use Standard for fine wake comparison.

The automatic Preview is time-bounded for responsiveness. A Preview budget stop is recorded in Summary and Diagnostics and does not require a startup correction. For Standard or Detailed, read any reported time or iteration limitation before using the result for comparison; inspect residual, mass drift, flux imbalance, repairs, and visual plausibility rather than treating color alone as proof of quality.

6.5 A practical refinement sequence

Escalate cost deliberately

1. Leave **Quality** unconnected for automatic **Standard** ; inspect geometry, wind direction, and reported dimensions as needed.
2. Save the Standard Summary and a representative image.
3. Duplicate the study or record baseline values.
4. Use **Detailed** quality only for shortlisted options or a sensitivity check.
5. Compare pattern location, wake width, acceleration zones, and scalar ranges, not only the maximum value.
6. State when conclusions change with resolution.

7

The Five Visualization Methods

All five methods read the same stored 3D result. Each method selects different paths, samples, surfaces, and scalar fields to answer a different design question.

7.1 Method 1: Detailed 3D Streamlines

Use Method 1 for the overall flow story. It selects a balanced family of upstream, roof, side, wake, and recirculation-sensitive paths and colors them by speed in meters per second. For the physical meaning and limits of streamlines, see section 8.4.

For a multi-building field, Method 1 evaluates downstream path candidates against the undisturbed incoming speed at the same height. It reserves a local wake bundle for every building whose calculated downstream region contains meaningful disturbance, then distributes that bundle across the wake's width and height before filling the remaining global path slots. One energetic building therefore cannot consume nearly every wake path, and a broad resolved wake is not represented only by a narrow core trace.

This is a display-coverage rule, not manufactured turbulence. AeroField does not add decorative curls where the calculated field contains no meaningful deficit, turning, or rotational activity. If a building appears to have a smooth or narrow wake, inspect the achieved resolution. If Preview was deliberately selected, return to Standard before treating that difference as a physical conclusion.

The automatic Standard field is a developed snapshot. Its balanced incoming variation can produce modest curvature or meander in calculated approach, roof-bypass, and side-bypass paths before and around the site. Remote paths should still follow the mean wind coherently, and the family should not drift systematically to one side. A path that remains locally straight is not an error; the variation is deliberately low-level and is modified by the calculated field.

Default composition:

- 150 target streamlines;
- 1.0-pixel detailed line width;
- Robust Global velocity color range;
- direct inlet-to-outlet traces through the calculated field, with wake-focused paths added only inside the calculated wake;
- full 3D paths with depth testing against the building.

Every ordinary Method 1 path is one continuous calculated trace from the solver inlet boundary to the solver outlet. Standard and Detailed provide equal $5H$ approach and wake space by default; Preview provides equal $4.5H$ space. Wake-focused paths may begin inside the calculated wake to make recirculation visible. **Upstream Approach H** is retained for compatibility and has no effect; increase **Upwind Domain H** only when the physical calculation needs more inlet-side space than the default. Detailed Streamlines and line width are also display or post-processing controls and reuse the field. **Detailed Line Width px** accepts 0.8 to 3.0 pixels: use the default 1.0 for balanced everyday review, 1.5 for a more legible typical viewport, and 2–3 for a large monitor, distant camera, or presentation capture. The setting changes only the stroke used to draw each path; it does not alter the field, solver resolution, or path geometry. In a dense view, wider strokes can merge adjacent paths and obscure fine bends or color transitions, so return to 1.0–1.5 for close comparison.

The calculated samples remain the source path. Method 1 draws bounded, piecewise tangent-continuous presentation curves through those samples. Every piece is checked against occupied building cells and against its source segment; only an unsafe local piece is replaced by conservative checked geometry. The smooth stroke is divided into contiguous color spans associated with exact physical source segments. Each span receives local velocity magnitude U by interpolation between that segment's neighboring samples, and one legend range is shared by all paths. Equal U values therefore receive equal colors. No dark outline is drawn beneath the colored curve, so close views remain solid rather than dotted or grainy. The Study component also suppresses its duplicate native Flow Paths and Analysis Plane previews; a separately connected downstream parameter can still add its own Grasshopper preview.

7.2 Reading one Method 1 study from three viewpoints

The camera determines which parts of a three-dimensional flow story can be read clearly. Figure 7.1 shows the same Method 1 field around two building assemblies: an arch made from three rectangular masses (two vertical supports and a horizontal lintel), plus a nearby truncated pyramid. The displayed family contains 150 paths with **Detailed Line Width px** increased from the default 1.0 to 1.5 for screen readability. This width is a presentation setting; it does not change the calculated field.

In the plan view, the building side above the objects is downstream because the wind travels upward in the viewport. The dense, turning family in that region indicates disturbed wake and recovery flow. The downstream-side view makes the sheltered region, side bypass, and roof bypass easier to see than the upstream view alone.

The path colors encode local speed according to the displayed legend: blue and cyan indicate the lower end of the shown range, while green, yellow, orange, and red indicate progressively higher speed. Do not identify turbulence from color alone. Read speed together with path direction, curvature, and the path's location relative to the downstream side of each form.

Prepare a clean presentation view

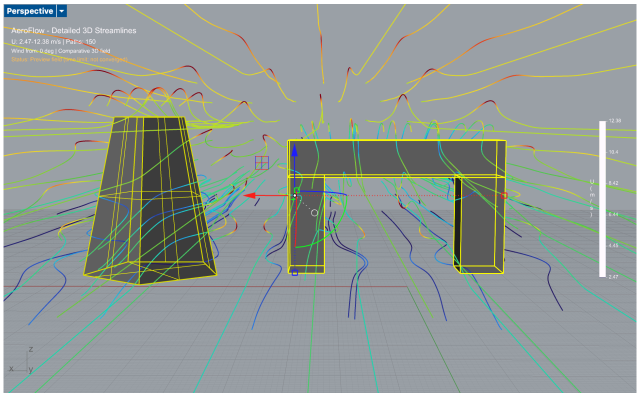
Before baking, exporting, or capturing a presentation image, deselect the source geometry and hide Rhino's Gumball. Selection outlines and transformation controls are working aids, not AeroField output. The example in figure 7.1 is a time-limited Preview field: use it to confirm overall organization, then use Standard when fine wake differences are important to a design comparison.

7.3 Method 2: Wake and Vortex

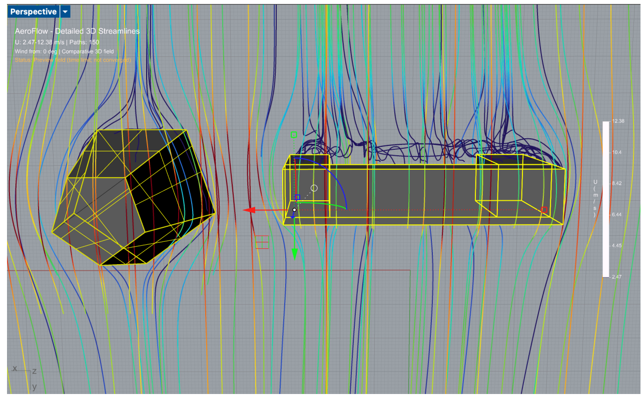
Method 2 emphasizes the downstream region. It combines selected guide paths with a translucent thresholded wake surface shaped by velocity-gradient behavior and colored by Speed-Up. Read the normalized ratio in section 8.2 and the wake/rotation indicators in section 8.5 before comparing its colors or surface extent.

Use it to ask:

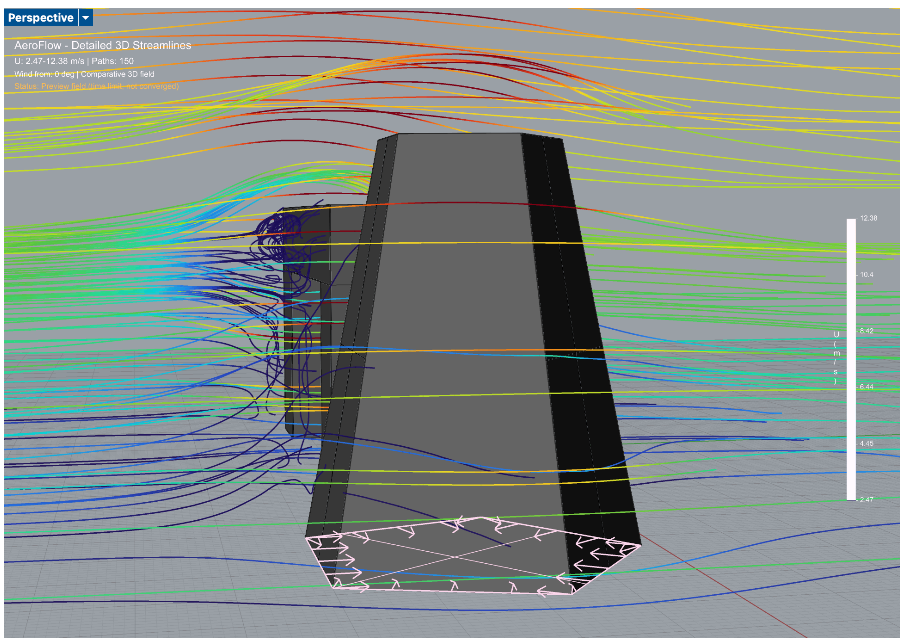
- where does the low-speed/rotational wake organize;



(a) Upstream elevation. The approach family separates around and above the forms; the wake is largely hidden behind them from this direction.



(b) Plan. Wind travels from the bottom toward the top of the view, making the downstream disturbed region easy to locate.



(c) Downstream-side view. Paths bend around the forms and reorganize after leaving the sheltered region.

Figure 7.1: One Method 1 field read from three camera positions. The upstream elevation checks incoming direction and roof-level deflection; the plan and downstream views reveal path curvature and the downstream recovery region more clearly. The yellow outlines and transformation gizmo are Rhino selection graphics, not AeroField output.

- how wide and tall is the affected region;
- do nearby forms split, shelter, or redirect the wake;
- where do guide paths indicate recirculating or strongly turning flow.

The wake surface is a filtered visualization, not a solid object or concentration cloud. Its boundary depends on the selected threshold and field resolution.

In the upper-left view of figure 7.2, the camera is turned slightly toward the downstream side of the same arch-and-tapered-form study used for Method 1. The wake surface shape follows vorticity magnitude, while the surface colors and guide-path colors use the local speed-up scale shown in the viewport. The tightly looping dark-blue paths in the sheltered gap identify the most strongly turning part of the displayed flow. Read the translucent surface as a thresholded locator for the wake, not as a solid boundary or a volume of air.

7.4 Method 3: Pedestrian Wind Map

Method 3 samples Speed-Up on a horizontal plane at **Analysis Height m** and adds projected contextual paths. The default height is 1.5 m above ground. Speed-Up is a same-height normalized ratio, defined in section 8.2.

Interpret the map as comparative acceleration and shelter:

- values below 1 indicate slower flow than the incoming reference at that height;
- values near 1 indicate similar speed;
- values above 1 indicate local acceleration;
- the standard fixed color range is 0 to 2.

This is not a pedestrian comfort classification. Comfort requires climate frequencies, directional weighting, exceedance criteria, activity categories, and validated methodology.

If Analysis Height lies outside the solved vertical range, Method 3 is omitted and Study reports a warning. Choose an in-domain height to generate the colored map. The upper-right view of figure 7.2 is an intentional example of this protection: its requested 1.5 m plane lies above the displayed 0 m to 0.11 m solved range. No pedestrian map is drawn; the remaining three-dimensional context paths are orientation aids, not pedestrian-plane data.

7.5 Method 4: Flow Sections

Method 4 creates a small atlas of bounded horizontal and vertical sections. The default Section Field is Speed-Up. Advanced Settings can choose speed, pressure proxy, vorticity, Q criterion, vertical velocity, world velocity components, divergence, flow disturbance, or speed deficit. The definitions, units, signedness, and cautions for these fields are collected in section 8.8.

Use sections to inspect vertical deflection, roof flow, side passages, centerline wake, and signed directional components that are difficult to understand from paths alone.

Scalar meshes are interpolated slices through the stored 3D field. They are not separate 2D calculations.

The lower-left view of figure 7.2 shows the same boundary condition in Method 4. The available vertical section and guide paths remain visible, but the horizontal section at 1.5 m is omitted rather than extrapolated beyond the stored field. The warning is part of the result: do not interpret an omitted horizontal slice as a low or uniform scalar field.

7.6 Method 5: Surface Exposure

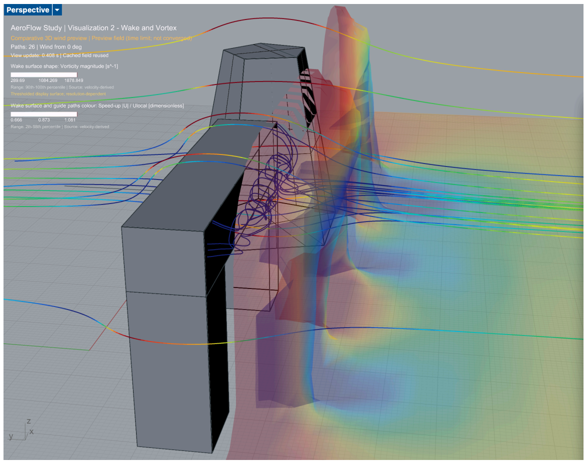
Method 5 samples the flow just outside building surfaces and colors a duplicate display mesh. It can show Speed-Up, Speed, or Pressure Proxy. Near-surface guide paths add directional context. For the difference between these quantities and the limits of facade-adjacent sampling, see sections 8.3 and 8.6.

Use it to compare which facade regions are more exposed or sheltered. Do not treat Pressure Proxy as facade pressure coefficient, cladding load, or structural pressure. The samples are offset into nearby fluid cells and smoothed once across similarly oriented mesh neighbors.

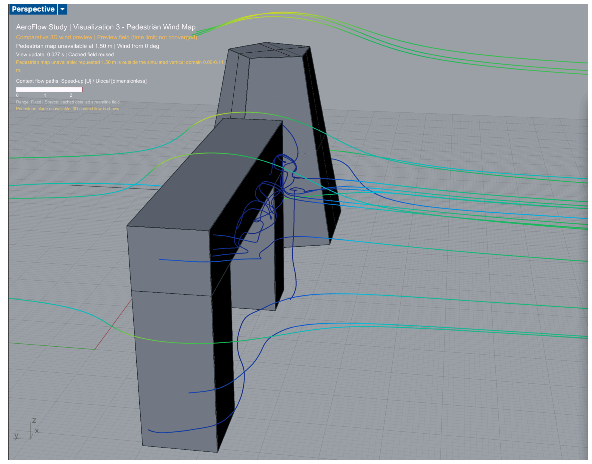
The lower-right view of figure 7.2 uses Speed-Up. AeroField intentionally colors the building display mesh, and its near-surface guide paths share the fixed 0–2 local speed-up scale. Compare facade and roof regions against that legend; the colors express relative velocity exposure, not pressure coefficients or facade loads.

7.7 Choosing a method

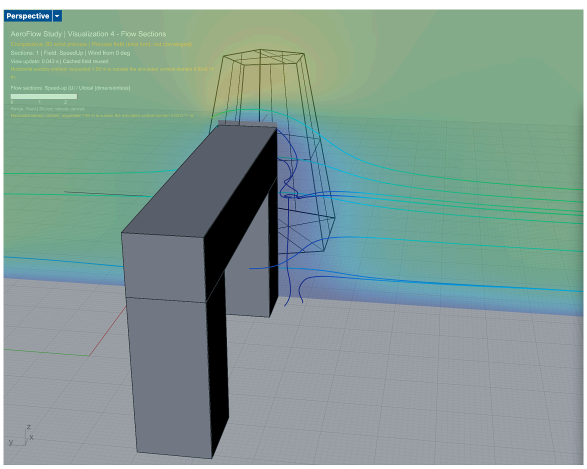
Design question	Recommended view
How does air go around and over the mass?	1 Detailed 3D Streamlines
Where is the downstream wake concentrated?	2 Wake and Vortex
Where are pedestrian-height acceleration and shelter?	3 Pedestrian Wind Map
What happens through a vertical or horizontal cut?	4 Flow Sections
Which facade regions are more exposed?	5 Surface Exposure



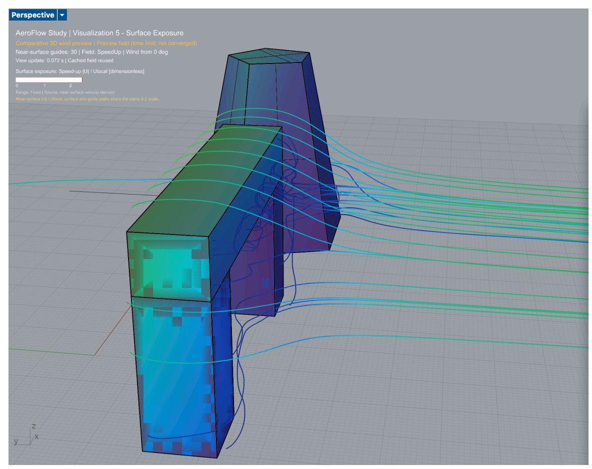
(a) Method 2, Wake and Vortex. The translucent surface locates a thresholded vorticity-based wake; colors use local speed-up.



(b) Method 3, Pedestrian Wind Map. The requested 1.5 m plane is outside the available vertical range, so only context paths appear.



(c) Method 4, Flow Sections. The remaining vertical section is shown while the unavailable horizontal slice is omitted.



(d) Method 5, Surface Exposure. The building mesh is intentionally colored by near-surface speed-up.

Figure 7.2: Methods 2–5 from the same oblique downstream camera. Each view reads the stored three-dimensional field differently. Methods 3 and 4 retain valid context when a requested horizontal plane lies beyond the available field; they do not invent an extrapolated scalar surface.

8

Flow Physics, Colors, and Scalar Fields

AeroField communicates an exterior three-dimensional velocity field. The physics chapter defines every displayed flow quantity, explains its normal interpretation, and states the limit beyond which a specialist study is needed.

8.1 The primary result: a three-dimensional velocity field

At each fluid location AeroField stores a three-component velocity vector,

$$\mathbf{U} = (U_x, U_y, U_z),$$

whose components are measured in m/s. The vector gives direction and magnitude. Its non-negative magnitude, called **Speed**, is

$$|\mathbf{U}| = \sqrt{U_x^2 + U_y^2 + U_z^2}.$$

Velocity X, **Velocity Y**, and **Velocity Z** are signed components in Rhino's world-coordinate system. Their signs do not mean upwind/downwind or left/right relative to a building. **Vertical Velocity** is the same world-Z component: positive means upward and negative means downward.

The result describes exterior air in the solved volume. Values inside a building mass are not air results. Likewise, AeroField does not extrapolate a requested horizontal plane above, below, or beyond the available field.

8.2 Speed-Up: the normalized comparison quantity

Speed-Up is a dimensionless ratio, not a speed in m/s:

$$S = \frac{|\mathbf{U}|}{U_{\text{ref}}(z)}.$$

Here $U_{\text{ref}}(z)$ is the undisturbed incoming speed at the same height above ground, z. For a Uniform wind profile it equals the Study's **Wind Speed m/s**. For a Power Law profile it normally changes with height. This same-height normalization removes ordinary vertical wind-profile variation before evaluating building-related acceleration or shelter.

Table 8.1: Physical reading of Speed-Up.

Value	Physical meaning	Design interpretation
$S = 1.0$	Local speed matches the undisturbed incoming reference at that height.	No local acceleration or speed loss is indicated by the ratio. The velocity direction can still be deflected.
$S > 1.0$	Local acceleration.	Look for side passages, corners, roof bypass, or channeling between buildings.
$S < 1.0$	Local speed reduction.	Look for shelter, wake, stagnation-facing regions, or reduced-flow pockets.
$S \approx 0$	Very low local speed compared with the reference.	Inspect path direction and the wake indicators before deciding whether the region is sheltered or recirculating.

Worked example. If $U_{\text{ref}}(z) = 5\,\text{m/s}$ and the local speed is 7.5 m/s, then $S = 1.50$. If the local speed is 3 m/s at the same reference height, then $S = 0.60$. The same 3 m/s has a different normalized meaning at a height where the undisturbed reference is different.

Methods 3 and 5 use a fixed 0–2 Speed-Up legend by default. On this scale, 0 is the low end, 1 is the local undisturbed reference, and 2 is twice the reference. Values beyond the shown endpoints use the endpoint colour; red on this fixed display means $S \geq 2$, not necessarily exactly 2.00.

8.3 Speed versus Speed-Up

Use **Speed** when the question is physical velocity in m/s: for example, how fast exterior air is moving at a known input wind. Use **Speed-Up** when the question is how strongly geometry changes the local flow relative to its incoming background.

The distinction matters with a height-varying profile. Roof-level speed can exceed pedestrian-level speed even in unobstructed air. A ratio near one says the speed is close to the incoming profile expected at that height; a ratio above or below one identifies a local departure associated with the modeled geometry.

8.4 What streamlines do, and do not, show

A streamline is a curve everywhere tangent to the stored velocity field. It is a directional drawing aid that shows how the displayed field bends around, over, and behind buildings. In Method 1, path colour normally represents local Speed in m/s; guide paths in the other methods commonly use Speed-Up. The active legend always identifies the quantity.

Streamlines are not measured smoke trails, do not establish travel time, and are not a measure of air volume or mass flow. Their display spacing follows a visualization seed policy rather than a physical flux. Read a streamline family by approach direction, deflection, curvature, and location relative to the building and the downstream region.

8.5 Wake, recirculation, and rotation

A **wake** is the downstream region in which a building has disturbed the incoming flow. It can contain lower speed, directional turning, local reverse flow, and gradual recovery. A wake is not a hard-edged object and it is not automatically a turbulent region.

Method 2 uses a thresholded rotational indicator to locate a wake-oriented surface. The surface supports comparison of wake position and organization, but its boundary changes with the display threshold and field resolution. It is neither a solid boundary nor a volume of material.

Table 8.2: Rotation and continuity indicators.

Field	Physical definition	Correct interpretation
Vorticity magnitude	Magnitude of the curl of velocity, $\lvert\nabla \times \mathbf{U}\rvert$, in 1/s.	Highlights local rotation and shear. High values can occur near walls and sharp turns; they are not turbulence intensity.
Q Criterion	Velocity-gradient quantity comparing local rotation with local strain, in 1/s^2.	Positive regions can help locate rotation-dominated structure. They do not prove turbulence or define a unique vortex boundary.
Divergence	$\nabla \cdot \mathbf{U}$, in 1/s.	A continuity-quality diagnostic. It should generally remain small away from boundaries in exterior incompressible flow. Local values can reflect gradients, sampling, or resolution sensitivity.

Turbulence intensity, turbulent kinetic energy, and comfort exceedance are different physical or statistical quantities. AeroField does not display them as certified engineering results. Do not infer them from a colourful or highly curved path alone.

8.6 Pressure Proxy and comparison indicators

Pressure Proxy is a signed velocity-derived comparison quantity reported in pascal-like units:

$$p_{\text{proxy}} = \tfrac{1}{2}\rho \left[U_{\text{ref}}(z)^2 - \lvert\mathbf{U}\rvert^2\right],$$

with $\rho = 1.225\,\text{kg}/\text{m}^3$ for this display quantity. It is positive where local speed is below the same-height incoming reference, negative where local speed is higher, and near zero where the two speeds match.

The proxy can help compare stagnation-facing and accelerated regions. It is not static pressure, pressure coefficient C_p, facade pressure, cladding load, or structural design load. A proxy value of zero means equal local and reference speed; it does not mean zero atmospheric pressure.

Table 8.3: Other velocity-derived comparison indicators.

Field	Definition or basis	Meaning and limit
Flow Disturbance	$\lvert 1 - S\rvert$, limited to the range 0–1.	Size of the departure from local incoming reference, whether faster or slower. It does not distinguish acceleration from deficit and is not turbulence intensity.
Speed Deficit	$\max(0, 1 - S)$.	Lower-speed portion of a wake or sheltered region. It is intentionally zero in accelerated regions.

Field	Definition or basis	Meaning and limit
Surface Exposure	Exterior-air samples adjacent to the displayed building surface.	Relative facade and roof exposure in Method 5; not wall shear, wall pressure, or a load calculation.

8.7 Color-map direction

The same colour has no universal meaning. Before interpreting any plot, identify the method, scalar field, units, legend endpoints, and range policy.

For unsigned sequential fields, dark blue represents the low end of the legend and dark red represents the high end. Intermediate stops pass through blue, cyan, green, yellow, and orange. Speed, Speed-Up, Vorticity magnitude, Flow Disturbance, and Speed Deficit are unsigned. Blue Speed-Up does not mean negative speed or cold air; it means the low end of the displayed ratio.

For signed fields, dark blue is the negative extreme, a light neutral colour is zero, and red is the positive extreme. Pressure Proxy, Q Criterion, Divergence, Vertical Velocity, and individual velocity components are signed. The legend numbers, not colour names alone, define meaning.

Figure 8.1: Sequential color direction. Actual legend numbers depend on the selected field and range policy.

8.8 Field directory

Table 8.4: Scalar fields available in Flow Sections.

Field	Units	Meaning and caution
Speed-Up	dimensionless	$S = \lvert\mathbf{U}\rvert / U_{\text{ref}}(z)$. A same-height local-reference ratio: 1 is the undisturbed reference, above 1 is faster, below 1 is slower.
Speed	m/s	Magnitude $\lvert\mathbf{U}\rvert$ of the local 3D velocity vector.
Pressure Proxy	Pa	$\frac{1}{2}\rho[U_{\text{ref}}(z)^2 - \lvert\mathbf{U}\rvert^2]$; signed comparative quantity, not C_p, facade pressure, or load.
Vorticity	1/s	Magnitude $\lvert\nabla \times \mathbf{U}\rvert$; local rotation/shear, highly resolution-sensitive near walls, not turbulence intensity.
Q Criterion	$1/s^2$	Signed rotation-versus-strain indicator; positive values can highlight rotation-dominated regions, not a unique vortex or proof of turbulence.
Vertical Velocity	m/s	Signed world Z velocity: positive upward, negative downward.
Velocity X	m/s	Signed world X component; not a wind-aligned component.
Velocity Y	m/s	Signed world Y component; not a wind-aligned component.
Velocity Z	m/s	Signed world Z component; equivalent to the Vertical Velocity field.
Divergence	1/s	Signed continuity-quality diagnostic; localized values can indicate gradient, sampling, or resolution sensitivity.
Flow Disturbance	dimensionless	$\lvert 1 - S\rvert$, limited to 0–1; magnitude of speed departure, not turbulence intensity.

Field	Units	Meaning and caution
Speed Deficit	dimensionless	max$(0, 1 - S)$; lower-speed fraction relative to local reference, zero in accelerated flow.

8.9 Why pressure and temperature are not interchangeable

AeroField does not calculate or display a temperature field. No energy equation, heat source, buoyancy coupling, or natural-ventilation model is part of the public Study. Any temperature-like interpretation would therefore be incorrect.

Pressure Proxy is computed from the relationship between local and undisturbed same-height speed. It often becomes positive where flow slows and negative where it accelerates, but it is not a calibrated static-pressure solution. Similar-looking spatial patterns between speed-derived quantities are expected because they share the same underlying velocity field.

8.10 Range policies

Detailed streamline color offers three policies:

- **Robust Global**: uses robust field percentiles to avoid a few extreme values flattening the colors; default;
- **Full Data**: maps the full finite minimum and maximum;
- **Fixed**: uses Fixed Color Minimum and Maximum supplied by the user.

Use a fixed range when comparing alternatives. Automatic ranges make each individual image readable but can assign the same red to different physical speeds. A value beyond a range endpoint is drawn with the endpoint colour, so inspect the numbers before treating an intense colour as a unique value.

Scalar sections use a fixed 0–2 range for Speed-Up, robust symmetric ranges centered on zero for signed fields, and robust percentile ranges for other fields. Legends report the actual endpoints.

8.11 Live legends and clean movies

Color Legends in Advanced Settings controls the live Rhino viewport. Set it false for uncluttered screenshots or when a separate publication legend is being composed. Movie exports always omit labels, colorbars, ticks, and axes regardless of the live setting.

9

Viewport Presentation and Communication

A strong technical image has a deliberate method, camera, scalar range, building appearance, and caption.

9.1 Live viewport controls

Advanced Settings provides two global switches:

- **Viewport Labels** shows the AeroField title, method, wind, path count, and result status;
- **Color Legends** shows numerical color ranges for the current method.

These are display-only. Turning them on or off does not rerun the field.

9.2 Building appearance

AeroField draws a neutral copy of the prepared building mesh so flow paths and scalar layers can be read against the mass. The original Grasshopper/Rhino preview can overlap this display if it remains enabled, producing unexpected colors or doubled edges. Hide the source geometry preview when preparing a clean image.

Visualization 5 deliberately colors a duplicate facade mesh because the surface field is the subject of that method. Other methods keep the building neutral.

9.3 Path thickness

Detailed Line Width px controls Visualization 1 between 0.8 and 3.0 pixels. **Context Line Width px** controls Methods 2 through 5 between 1 and 4 pixels. These are viewport widths, not solid Rhino cylinders.

For ordinary screens, defaults preserve separation between nearby curves. Increase Context Line Width for projected presentations. Bake curves when true Rhino curve objects, custom materials, or rendered pipe geometry are needed.

9.4 Camera recipes

9.4.1 Analytical top view

Use parallel projection, orient the camera normal to the ground, and align the wind horizontally or vertically on screen. This is best for comparing wake direction, lateral symmetry, passage acceleration, and pedestrian maps.

9.4.2 Wind-source elevation

Look directly along the travel direction. Use this view to inspect vertical lift, roof crossing, and left/right balance. A perfectly symmetric building under a cardinal wind should not exhibit a systematic lateral lean in the underlying field.

9.4.3 Presentation perspective

Use a moderate lens, keep the building readable, and leave visible approach and wake space. Avoid extreme wide-angle distortion. Increase Upwind Domain H only when the calculation needs a longer physical inlet region.

9.5 Caption template

```
AeroField comparative exterior wind preview.
Standard quality; wind from 270 degrees at 10 m/s.
Visualization 3: speed-up at 1.5 m above ground; range 0-2.
Result status: <status>. Early-design comparison; not comfort certification.
```

9.6 Comparison boards

When placing alternatives side by side, keep these fixed:

- wind speed and Wind From direction;
- quality, actual resolution, and domain policy;
- visualization method and scalar field;
- color range endpoints;
- Analysis Height;
- camera family, projection, crop, and image dimensions;
- visibility of labels and legends.

If one of these changes, label it conspicuously. Visual consistency is part of analytical honesty.

REFERENCE MANUAL

Complete behavior of the three public components, all advanced controls, result reuse, animation, baking, and outputs.

10

Public Component Reference

AeroField exposes three components in the AeroField/Wind tab. Study is the complete normal workflow; Advanced Settings and Animation Export are optional companions.

10.1 AeroField Study

AeroField Study accepts building geometry and wind conditions, computes the 3D field, creates the selected visualization, draws it directly in Rhino, and provides outputs for downstream Grasshopper use.

10.1.1 Inputs

Table 10.1: AeroField Study inputs.

No.	Input	Default	Behavior
0	Buildings	required list	Closed building masses or meshes. Open/invalid geometry can use conservative fallback occupancy with a warning.
1	Wind Speed m/s	10	Reference incoming wind speed. Valid range $(0, 100]$.
2	Wind From degrees	0	Meteorological source direction; values wrap around 360°.
3	Analysis Height m	1.5	Height above ground used by Pedestrian Wind Map and horizontal Flow Sections. Display sampling only.
4	Quality	Standard when unconnected	Preview, Standard, or Detailed preset.
5	Advanced Settings	empty	Optional typed output from AeroField Advanced Settings. When connected, its Base Quality and overrides are authoritative.

Study computes automatically when relevant inputs change. There is no Run input. To stop a long operation, right-click Study and choose **Cancel current solve**; the last valid result remains available when possible.

10.1.2 Visualization buttons

Five numbered buttons select Detailed 3D Streamlines, Wake and Vortex, Pedestrian Wind Map, Flow Sections, and Surface Exposure. The selection is saved with the Grasshopper definition. Clicking a button updates the post-processing and display while reusing the stored field.

10.1.3 Bake button

BAKE VIEW TO RHINO creates persistent Rhino objects for the current method. The button is disabled until a valid visualization exists. The standard Grasshopper bake command is also supported.

10.1.4 Outputs

Output	Type	Description
Summary	Text item	Human-readable study status, wind, geometry, grid, resolution, timing, paths, and interpretation limits.
Flow Paths	Curve list	Current method's bakeable path curves. Connect to Curve parameters for additional Grasshopper operations.
Analysis Plane	Mesh item	Primary horizontal analysis mesh when the selected method provides one.
Study	Generic item	Complete result consumed by AeroField Animation Export.
Diagnostics	Text list	Detailed geometry, grid, field-health, caching, path, sampling, scalar, and method messages.

No output connection is needed to see the result. Study implements Grasshopper custom preview and draws directly in the active Rhino viewport.

10.2 AeroField Advanced Settings

AeroField Advanced Settings begins with a Base Quality preset. Inputs 1 through 23 are optional overrides: a disconnected port inherits the selected preset; a connected port becomes authoritative. This makes the component adaptable without showing misleading fixed values when Base Quality changes.

Connect:

```
AeroField Advanced Settings.Advanced Settings
  -> AeroField Study.Advanced Settings
```

Its Summary output lists the resolved quality, resolution, profile, domain, streamline composition, scalar fields, and live overlay state.

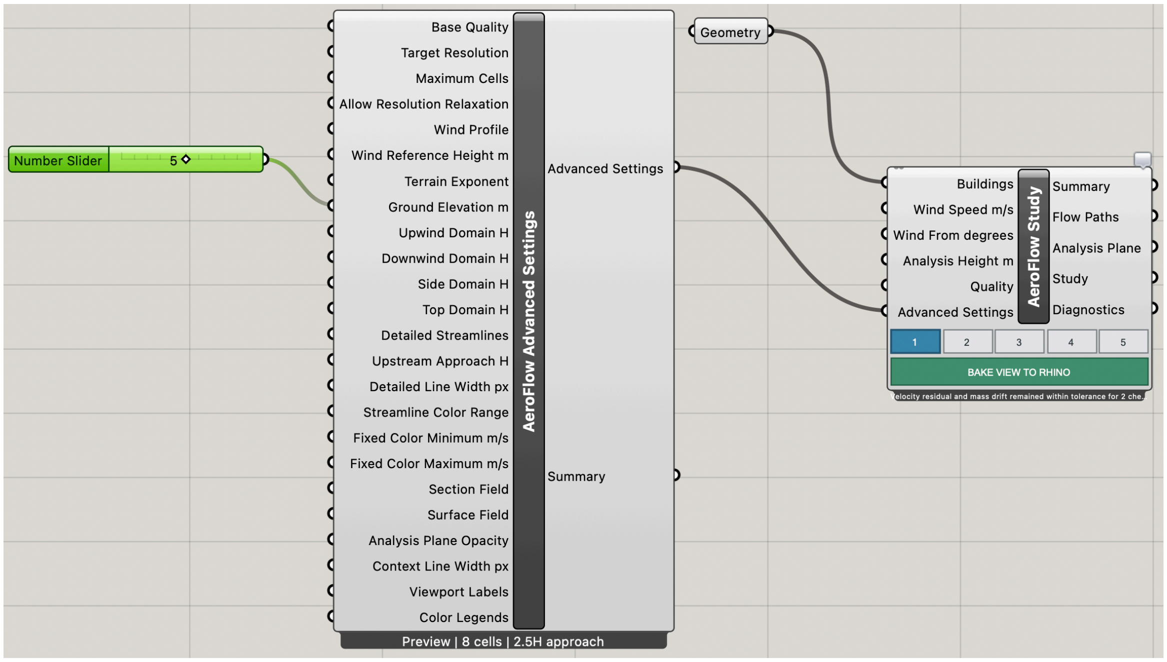


Figure 10.1: An Advanced Settings workflow. The component's **Advanced Settings** output is connected to the Study component's **Advanced Settings** input. The Number Slider is connected to **Ground Elevation m** as an illustrative override; all other advanced inputs remain available for selective control.

10.3 AeroField Animation Export

The compact movie component has one input and one output:

Port	Type	Purpose
Study input	Generic item	Connect AeroField Study's Study output.
Movie Path output	Text item	Last successfully generated movie path.

EXPORT MOVIE writes to the default Documents/AeroField/Movies folder. **SAVE AS...** opens the native format-aware dialog. Right-click options open or reveal the last successful movie.

10.4 Why these three components

The interface intentionally separates three tasks:

- Study contains the common analytical workflow and direct view selection;
- Advanced Settings contains uncommon but meaningful overrides;
- Animation Export contains a single export workflow that prepares frames ahead of the save request.

The ordinary canvas remains readable because normal operation stays in Study. Less frequently used controls are grouped in Advanced Settings, while movie saving remains a separate one-wire action.

11

Advanced Settings Directory

Advanced Settings is optional. It supplies a quality preset plus selective overrides: connect the output to Study, then connect only the controls you want to change.

The complete directory below uses Standard values as concrete numeric references so that the scale of each control is easy to understand. The actual inherited value depends on the selected Base Quality preset; the preset comparison table later in this chapter shows the differences between Preview, Standard, and Detailed.

Table 11.1: Complete Advanced Settings input directory.

No.	Input	Standard reference	Effect
0	Base Quality	Standard	Selects Preview, Standard, or Detailed defaults before connected overrides are applied.
1	Target Resolution	24	Cells across the smallest significant building dimension; 6–64. Recalculates field.
2	Maximum Cells	1,500,000	Complete 3D field budget; 30,000–2,500,000. Automatic multi-building Preview can use a bounded expanded site allowance. Recalculates grid/field if effective.
3	Allow Resolution Relaxation	false	Allows actual resolution to fall below target to fit Maximum Cells; reports tradeoff.
4	Wind Profile	Power Law	Power Law or Uniform incoming speed with height. Recalculates field.
5	Wind Reference Height m	disconnected	Connecting a positive height defines Wind Speed at that absolute height.
6	Terrain Exponent	0.22	Power-law vertical shear; accepted range 0–1. Recalculates field.
7	Ground Elevation m	inferred	Optional physical world Z ground elevation. Rebuilds preparation and field.
8	Upwind Domain H	5.0	Solved approach extent; Standard and Detailed match the 5H downwind extent. Preview uses 4.5H on both sides. Minimum 1H. Rebuilds grid/field.
9	Downwind Domain H	5.0	Solved wake extent; minimum 3H. Rebuilds grid/field.
10	Side Domain H	1.5	Clearance on each lateral side; minimum 1H. Rebuilds grid/-field.
11	Top Domain H	1.0	Clearance above tallest mass; minimum 1H. Rebuilds grid/-field.
12	Detailed Streamlines	150	Visualization 1 target count; 120–180. Rebuilds detailed paths, not field.

No.	Input	Standard reference	Effect
13	Upstream Approach H	Compatibility input	Retained for older Grasshopper definitions and ignored by current versions. Use Upwind Domain H for a longer physical inlet region.
14	Detailed Line Width px	1.0	Visualization 1 viewport width; 0.8–3.0. Display only.
15	Streamline Color Range	Robust Global	Robust Global, Fixed, or Full Data. Display only.
16	Fixed Color Minimum m/s	0	Used only when Fixed color range is selected.
17	Fixed Color Maximum m/s	20	Must exceed Fixed Color Minimum.
18	Section Field	Speed-Up	Visualization 4 scalar field. Reuses stored field and rebuilds section display.
19	Surface Field	Speed-Up	Visualization 5 field: Speed-Up, Speed, or Pressure Proxy.
20	Analysis Plane Opacity	0.25	Scalar surface opacity from 0 to 1. Display only.
21	Context Line Width px	2	Path width for Methods 2–5; 1–4. Display only.
22	Viewport Labels	true	Toggles live title, method, wind, and status text. Movie frames always omit it.
23	Color Legends	true	Toggles live colorbars, labels, ticks, and axes. Movie frames always omit them.

11.1 How to read the component

Advanced Settings is a control bank, not a second Study component. It does not calculate a field by itself. Its output carries one resolved settings package to the Study component. The Study remains responsible for the calculation and the Rhino display.

The component follows a simple inheritance rule:

1. If **Base Quality** is disconnected, the component starts from the `Standard` preset.
2. If **Base Quality** is connected to `Preview` or `Detailed`, that preset becomes the starting point.
3. Every disconnected port inherits its value from that preset.
4. Every connected port overrides the inherited value.

When the Advanced Settings output is connected, it is authoritative and the Study component's **Quality** input is ignored. This is why the normal wiring uses one settings wire plus only the specific override wires required by the study.

One override is enough

To change only the ground elevation, connect Advanced Settings to Study and connect a Number Slider or Panel containing `5` to **Ground Elevation m**. Leave every other port disconnected. The study uses the Standard preset plus that one ground override.

11.2 Choosing the right kind of control

The input directory below is easiest to use when the ports are divided into three groups:

- **Numerical field controls**: Target Resolution, Maximum Cells, Allow Resolution Relaxation, Wind Profile, Wind Reference Height, Terrain Exponent, Ground Elevation, and the four solved-domain extents. These can require a new preparation or field calculation.
- **Path and scalar controls**: Detailed Streamlines, line widths, color range, Section Field, and Surface Field. These reuse the stored field but may rebuild paths or resample displays. Upstream Approach H is retained only for compatibility and has no current effect.
- **Viewport controls**: Analysis Plane Opacity, Context Line Width, Viewport Labels, and Color Legends. These change live presentation only.

Method 1 displays only direct calculated traces. If the physical inlet region needs more room, increase **Upwind Domain H**; this enlarges the solved field and repeats the calculation. If the goal is a different scalar map, change **Section Field** or **Surface Field**; do not rerun the numerical study unnecessarily.

11.3 Preset defaults

Property	Preview	Standard	Detailed	Note
Target Resolution	8	24	32	Cells across resolution-driving mass.
Maximum Cells	120,000 base	1,500,000	2,000,000	Base field budget. Multi-building Preview may expand automatically up to 1,500,000 cells.
Field character	Smooth mean-flow check	Developed evolving snapshot	Longer evolving snapshot	Standard uses balanced 3% inlet variation.
Upwind Domain	4.5H	5.0H	5.0H	Solved approach; matches the downwind extent in every preset.
Downwind Domain	4.5H	5.0H	5.0H	Solved domain.
Side Domain	1.5H	1.5H	1.5H	Each side.
Top Domain	1.25H	1.0H	1.0H	Above tallest mass.
Maximum time	8 s initial	55 s	300 s	Field time guard. Multi-building Preview may add one bounded local-wake pass of up to 8 s; Standard and Detailed are explicit.
General path count	44	56	72	Contextual path generation.
Detailed streamlines	150	150	150	Public display default.
Upstream Approach H	compatibility	compatibility	compatibility	Retained for older definitions; use Upwind Domain H for physical inlet extent.

11.4 High-value adjustments

The most useful overrides for ordinary design work are:

- Upwind Domain H when the physical inlet region needs more calculated space;
- Detailed Streamlines for path density;

- Section Field and Surface Field for different analytical questions;
- Viewport Labels and Color Legends for live presentation cleanup;
- Target Resolution and Maximum Cells for an intentional sensitivity study;
- domain extents when site boundaries are visibly too close.

Leave every other port disconnected unless there is a specific reason to change it.

11.5 Worked examples

11.5.1 Select Standard quality with one connection

Use the Standard preset

1. Add **AeroField Advanced Settings** and connect its **Advanced Settings** output to Study's **Advanced Settings** input.
2. Place a Panel containing `Standard` and connect it to **Base Quality**.
3. Leave the other advanced ports disconnected.
4. Read Summary after the solve. It should report the effective target, cell budget, and actual resolution.

This selects the Standard inherited values, including a 24-cell target and a 1,500,000-cell budget, without requiring 23 additional wires. The Study Quality input is ignored while the Advanced Settings output is connected.

11.5.2 Select Preview and enlarge the physical inlet region

Connect Advanced Settings to Study, connect a Panel containing `Preview` to Base Quality, and connect a Number Slider set to `6.0` to **Upwind Domain H**. This adds $1.5H$ of calculated inlet-side space beyond Preview's $4.5H$ default. The field is recalculated and may use more cells, but each displayed incoming path remains one continuous trace from the solved inlet boundary to the solved outlet.

11.5.3 Set an explicit ground elevation

If the model sits at world Z=5 m, connect a Panel containing `5` to **Ground Elevation m**. This tells AeroField where physical ground is; it does not move the Rhino geometry. Analysis Height is then measured upward from that ground. Confirm the interpreted elevation in Summary and Diagnostics.

11.5.4 Compare two resolutions

Keep geometry, wind, domain extents, camera, and color policy unchanged. Run one study with Standard, record actual cells across and total cells, then duplicate the branch and connect a different **Target Resolution**, such as 16 or 28. If the requested target cannot fit **Maximum Cells**, either raise the budget after checking available memory or enable **Allow Resolution Relaxation** and record the achieved coarser value. Never describe a relaxed 18-cell result as a 24-cell result.

11.5.5 Show a pressure-proxy section without a new solve

Connect Advanced Settings to Study, connect a Panel containing `Pressure Proxy` to **Section Field**, and select Study method 4. The section is rebuilt from the stored field. Read the legend and Diagnostics to confirm the field and range. This is a comparative velocity-derived display, not a calibrated pressure-load result; its physical definition and limitations are in section 8.6.

11.5.6 Understand what will recalculate

Change	Expected work
Target Resolution, Maximum Cells, or relaxation	Replans the field and may repeat the calculation.
Wind Profile, Reference Height, or Terrain Exponent	Rebuilds the incoming condition and repeats the calculation.
Ground Elevation or solved domain extent	Rebuilds the prepared domain and repeats the calculation.
Detailed Streamlines	Rebuilds detailed paths from the stored field.
Upstream Approach H	Compatibility input; no effect in current versions.
Line width or color range	Updates display without a new field solve.
Section Field, Surface Field, or plane opacity	Resamples or recolors the existing result.
Context width, Viewport Labels, or Color Legends	Updates live presentation only.

The distinction matters when a 3D study takes minutes. Changing a scalar field, legend, label, or line width should be a post-processing update; changing the numerical domain or inlet profile is a new study.

12

Calculation and Result Reuse

AeroField separates geometry preparation and the expensive 3D field from path generation, scalar sampling, method composition, and drawing. A change should repeat only the work it affects.

12.1 Work hierarchy

1. Geometry, units, ground, wind-aligned domain, and occupied cells

↓

2. Three-dimensional velocity field and field-health information

↓

3. Detailed paths and derived scalar fields

↓

4. Method-specific selections, planes, surfaces, colors, labels, and legends

↓

5. Bake or fixed-camera movie frames

Figure 12.1: AeroField retains higher-cost results so display-only changes remain interactive.

12.2 Expected effect of common changes

Table 12.1: Recalculation behavior.

Change	3D field	Paths/samples	Visible effect
Building geometry	Recalculate	Rebuild	Complete study update
Rhino units or ground	Recalculate	Rebuild	Complete study update

Change	3D field	Paths/samples	Visible effect
Wind speed or direction	Recalculate	Rebuild	Complete study update
Quality or resolution	Recalculate	Rebuild	Complete study update
Domain or wind profile	Recalculate	Rebuild	Complete study update
Analysis Height	Reuse	Resample plane	Methods 3/4 update
Visualization button	Reuse	Reuse/select	Method composition update
Section or Surface Field	Reuse	Resample/recolor	Scalar display update
Detailed Streamlines	Reuse	Rebuild detailed paths	Method 1 update
Upstream Approach H	Compatibility only	Compatibility only	No effect in current versions
Line widths	Reuse	Reuse	Immediate redraw
Viewport Labels/Legends	Reuse	Reuse	Immediate redraw
Movie save format	Reuse	Reuse prepared frames	Encoding only

12.3 Cache lifetime

The Study component retains prepared geometry, field results, path sets, analysis planes, and method results in memory. Restarting Rhino clears this memory. Replacing the Study component creates a new cache owner. Saving and reopening a Grasshopper definition preserves inputs and selected view, but not the entire in-memory field.

Movie frames are prepared on disk under Documents/AeroField/Prepared Movie Frames. Their identity includes the Study, visualization, dimensions, background, and stable active-camera properties. A changed camera prepares a new set.

12.4 Why a display change can still take time

Selecting a method does not recalculate the 3D field, but first use can still require path selection, derived-field calculation, plane sampling, facade sampling, contours, or wake-surface extraction. Subsequent use of the same method is normally faster because its result is retained.

13

Flow Field and Visualization Model

This chapter explains what users can infer from the calculated volume and its displays.

13.1 Uniform 3D field

AeroField computes velocity on a uniform, wind-aligned three-dimensional Cartesian field. Cell spacing is the same in all directions. Buildings and the ground occupy solid cells; the fluid region begins at ground and extends upwind, downwind, laterally, and upward according to the current domain.

Uniform spacing makes resolution easy to state as cell size and cells across a mass. It also means refinement applies throughout the domain. AeroField does not expose body-fitted layers, local octree refinement, or wall-function controls in the public interface.

13.2 Boundary behavior

At the incoming boundary, AeroField applies the selected vertical wind profile. Standard and Detailed also apply a reproducible cross-flow variation; Standard uses a default magnitude of 3 percent of the local incoming speed. The lateral and vertical contributions are balanced across the inlet, preserving zero net cross-flow and the specified mean wind direction. Preview omits this evolving variation. The downstream boundary allows flow to leave the domain. Side and top boundaries permit tangential flow. Ground and occupied building cells enforce stationary solid behavior.

The wall shape is represented at field resolution. A curved facade or narrow slot can become stepped or disappear when it spans too few cells. Raising Target Resolution improves geometric representation everywhere and increases cost rapidly.

13.3 Streamlines

A streamline is tangent to the stored velocity direction. AeroField traces paths with adaptive steps, checks proposed segments against solid occupancy, and stops at domain exit, persistent very-low speed, a wall, loop detection, or path limits.

For Method 1, AeroField presents the collision-checked path samples as bounded, piecewise tangent-continuous curves. Every piece is validated independently: it must remain within a small fraction of one field cell from its checked source segment, and dense validation samples must remain outside every occupied cell. If a piece fails either test, AeroField keeps the conservative source segment for that local interval instead of discarding smoothing along the complete path. This removes drawing kinks without moving a streamline through a building or inventing a different flow path.

Each visible Method 1 curve is divided into contiguous colour spans. Every span belongs to one exact physical source segment and receives velocity magnitude, $U = \|\mathbf{U}\|$, by interpolation only between that segment's neighbouring samples. The single *U (m/s)* legend maps equal velocity values to equal colours across all paths; colours are not assigned randomly by path or seed. There is no contrasting backing stroke, so the coloured curve itself is the complete streamline.

Because Standard stores a developed evolving snapshot, its calculated approach and bypass paths can show low-level meander before and around the site. The variation comes from the velocity field, not from a drawing filter, and does not represent a direct turbulence-intensity measurement. Preview normally appears smoother. Method 1 follows ordinary paths continuously from the solved inlet boundary through the field; wake-focused paths may begin inside the calculated wake. There is no external continuation to distinguish from the calculated flow.

Streamlines are not smoke mass, pollutant concentration, thermal plumes, or physical tubes of constant flow. Their apparent density reflects the seed policy as well as the field. Use them to read direction and organization, not to measure volumetric flow from line spacing.

13.4 Tall and slender buildings

AeroField does not impose an absolute maximum building height. The calculated domain includes the full occupied height and adds the configured Top Domain clearance above the tallest mass. A tall, slender building can nevertheless be expensive: its height enlarges the domain while its narrow plan dimension demands a small cell size.

For the untouched Standard preset, AeroField automatically uses the finest full-height field that fits the 1,500,000-cell budget when a tall, slender single building cannot fit the nominal 24-cell target. This bounded fallback can reach the Preview floor of 8 cells across the narrowest significant dimension. The component remains usable and reports the achieved resolution, the strategy, and a remark that narrow facade and wake details may be under-resolved. The tower and the configured clearance above it remain in the solved domain; only the cell spacing is coarsened to stay within the memory guard. To insist on a particular target, connect Advanced Settings, raise paramMaximum Cells if the computer can support it, or enable paramAllow Resolution Relaxation and record the achieved value. Standard and Detailed remain sensitive to resolution because a coarse tower width can distort separation, facade exposure, and wake width. Before interpreting a tall-building wake, verify that the narrowest important tower dimension spans enough cells for the comparison being made.

13.5 Three-dimensionality

Detailed paths can vary in X, Y, and Z. Roof paths lift, side paths turn laterally, and wake paths can descend, curl, or reverse locally. Pedestrian maps and Flow Sections are two-dimensional samples of this 3D field. Surface Exposure samples just outside the 3D building surfaces.

13.6 Near-wall interpretation

Sampling near solid cells uses available surrounding fluid information while respecting wall separation. Paths are collision-checked so they stop rather than pass through buildings. These measures improve visual coherence, but the near-wall region remains sensitive to cell size and stepped geometry.

Do not infer facade shear, boundary-layer thickness, separation location to engineering precision, or pedestrian values immediately adjacent to a coarse wall. Use a resolution study and specialist analysis when those quantities govern decisions.

13.7 Symmetry and bias

For a symmetric cube, centered domain, cardinal wind, and uniform setup, the mean field should be mirror-symmetric within numerical tolerance. An evolving snapshot can give individual paths different instantaneous bends, and the displayed subset can look slightly uneven because it selects a finite family of non-overlapping paths. The balanced inlet variation adds no net cross-flow, so a systematic lateral drift of the family is not expected.

Check apparent bias using Top and wind-source elevation in parallel projection. Confirm wind direction, source geometry, object transforms, and camera alignment. Compare scalar fields or denser paths before concluding that a sparse streamline subset represents a field asymmetry.

14

Animation Export Reference

Animation Export prepares a small Full HD frame set as soon as a Study is connected, then saves or encodes those frames when requested.

14.1 Defaults

Property	Compact movie behavior
Style	Moving bright packets over the current fixed paths
Duration	2 seconds
Prepared frames	2, 4, or 8 according to capture speed
Minimum frame separation	Half an animation cycle
Dimensions	1920 by 1080 pixels
Camera	Fixed active Rhino viewport
Background	White presentation background
Text and legends	Always omitted from exported frames
Grid and axes	Omitted
Field calculation	Reuses connected Study; never runs a new wind calculation

14.2 Local format discovery

At startup, AeroField searches the local PATH and common installation locations for `ffmpeg`, then probes available video encoders and containers. The Save As dialog lists only compatible recipes found locally.

Supported recipes can include:

- MP4 with H.264;
- QuickTime MOV with H.264;
- WebM with VP9 or VP8;
- Matroska MKV;
- AVI with Motion JPEG;

- animated GIF;
- animated PNG.

The exact list differs between computers. MP4 is the preferred general-purpose format; MOV is convenient for QuickTime-oriented workflows; WebM suits browser delivery; animated PNG is lossless but can be large.

14.3 Output folders

Automatic exports are stored in:

```
Documents/AeroField/Movies/
```

Each export also creates a timestamped frame folder containing PNG frames and a JSON manifest. Prepared working frames are stored separately under Documents/AeroField/Prepared Movie Frames.

14.4 Failure behavior

If encoding is unavailable or fails, the PNG frames remain so the visual work is not lost. The component reports the frames folder and preserves the last successful Movie Path. Install or repair `ffmpeg`, then export again.

14.5 Clean-frame guarantee

Every exported frame omits AeroField foreground overlays regardless of the live Advanced Settings. Rhino grid lines and grid axes are also omitted.

15

Baking, Summary, and Diagnostics

Baking creates editable Rhino objects; Summary and Diagnostics preserve the information needed to interpret and troubleshoot the study.

15.1 Baked object types

Depending on the selected method, AeroField bakes:

- streamline curves;
- colored scalar meshes;
- contour line segments;
- section and guide lines;
- an analysis-plane mesh when applicable.

Live viewport text and legends are not Rhino geometry and are not baked. Add annotations using Rhino layouts, text objects, or external publishing tools.

15.2 Flow Paths output versus Bake

The **Flow Paths** output is useful when Grasshopper should transform, filter, measure, pipe, or otherwise process the current path curves. The Bake button creates the whole current visualization with consistent layer roles and metadata. Both represent the same current method selection.

15.3 Summary

Summary is intended for a Panel and records:

- result state and selected visualization;
- quality and wind conditions;
- building count and resolution-driving dimension;

- field dimensions, total cells, cell size, and actual resolution;
- iteration and residual information;
- timing and path counts;
- Rhino units, characteristic height, ground, and analysis-height information;
- maximum speed-up and a comparative-use limitation.

Keep Summary with screenshots and design-option records.

15.4 Diagnostics

Diagnostics is more detailed and is intended for troubleshooting or technical review. It includes geometry preparation, fallback, domain and grid planning, result health, cache hits, scalar sampling, path counts, rejected paths, wall contacts, wake statistics, method timing, and availability messages.

Connect Diagnostics to a Panel when Study is orange or red, when a method appears empty, when actual resolution differs from target, or when documenting a sensitivity study.

15.5 Recommended record set

For each important option, retain:

1. Rhino and Grasshopper files;
2. Summary text;
3. Diagnostics text when warnings exist;
4. one labeled live screenshot or publication caption;
5. baked Rhino geometry when downstream rendering is required;
6. movie and retained frame folder when animation is archived.

IV

OPERATIONS

Installation, repeatable study protocols, troubleshooting, performance, and responsible interpretation.

16

Installation on Rhino 8

AeroField runs in Grasshopper for Rhino 8.30 or newer on macOS and Windows. The current Rhino 8 service release is recommended. Install one copy of the plugin and restart Rhino completely after changing plugin files.

16.1 Package contents

The runtime package contains:

- `AeroField.gha`, the Grasshopper plugin;
- `AeroField.Core.dll`, the calculation library;
- installation and quick-start documentation;
- the AeroField User Guide PDF;
- license and package information.

Keep the GHA and core DLL together. Do not rename or separate the dependency.

16.2 Preferred installation

When AeroField is available through Rhino Package Manager, use Rhino's **PackageManager** command, search for AeroField, install the Rhino 8 package, quit Rhino, and reopen it. Package Manager controls the installation folder and future updates.

For a downloaded Food4Rhino ZIP, follow the included platform instructions. A manual installation normally places the two runtime files in Grasshopper's Libraries folder or a configured search folder, then requires a complete Rhino restart.

16.3 macOS manual installation

Install from ZIP on macOS

1. Quit Rhino completely.
2. Expand the AeroField macOS ZIP.
3. Copy `AeroField.gha` and `AeroField.Core.dll` together into the Grasshopper Libraries folder specified by the package instructions.
4. Remove any older AeroField copy from other Grasshopper Libraries or Package Manager folders.
5. Reopen Rhino, launch Grasshopper, and confirm the AeroField tab shows Study, Advanced Settings, and Animation Export.

If macOS quarantines a manually downloaded file, use Finder's Open/Allow workflow or the security guidance supplied with the distribution. Do not disable system-wide security protections.

16.4 Windows manual installation

Install from ZIP on Windows

1. Quit Rhino completely.
2. Expand the AeroField Windows ZIP.
3. In File Explorer, open Properties for downloaded GHA/DLL files and choose Unblock if Windows shows that option.
4. Copy `AeroField.gha` and `AeroField.Core.dll` together into Grasshopper's Libraries folder.
5. Remove any older AeroField copy from other plugin or package folders.
6. Reopen Rhino and confirm the three AeroField components appear.

16.5 Avoid duplicate assemblies

Grasshopper cannot load two files with the same assembly identity, even if the visible filenames differ. A common conflict is one manual Libraries copy plus one Package Manager copy.

If a conflict dialog appears, record both paths, close Rhino, remove the unintended copy, and restart. Do not choose one at every launch; resolve the duplicate on disk.

Figure 16.1: A duplicate assembly conflict. Keep the intended current installation and remove the other copy.

16.6 Movie encoder

AeroField needs `ffmpeg` to produce encoded movie files. The plugin scans PATH and common installation locations. If it is absent, the Study and all static visualizations still work; movie PNG frames and their manifest can still be retained.

Install `ffmpeg` using a trusted package or system installer appropriate to the platform, then restart Rhino so the process receives the updated PATH.

17

Recommended Study Workflows

Repeatable comparisons keep geometry scope, wind assumptions, resolution, visualization, scalar range, and camera policy under control.

17.1 Standard workflow

Create a comparison study

1. Save a dedicated analysis copy of the Rhino model.
2. Confirm units and simplify exterior masses.
3. Connect buildings to Study and use Preview.
4. Verify Wind From, wind speed, ground, scale, occupancy, and general flow direction.
5. Switch to Standard and wait for the final status.
6. Save Summary and Diagnostics in Panels.
7. Choose the visualization that answers the design question.
8. Bake or export a movie only after camera and display ranges are deliberate.

17.2 General 3D composition

Use Visualization 1 at Standard quality. Start with 150 streamlines, 1.0-pixel detailed width, and Robust Global colors. This is the most useful overview for field interpretation and geometry diagnostics.

Increase Upwind Domain H only when the inlet side needs more calculated space. This repeats the field calculation but keeps the displayed paths as direct physical traces.

17.3 Wake comparison

Use Visualization 2 with the same wind, quality, and camera-relative orientation for every option. Compare wake position, width, height, connectivity, reverse-flow clues, and whether nearby forms split or reinforce the downstream region. The physical reading and threshold limitation of the wake surface are explained in section 8.5.

Do not compare two automatic color legends as if equal colors represented equal values. Record the legend endpoints or use an equivalent fixed policy where available.

17.4 Pedestrian-height comparison

Use Visualization 3 and an Analysis Height appropriate to the study, commonly 1.5 m. Keep the 0–2 Speed-Up range, height, wind, and camera fixed. Compare area and location of acceleration or shelter rather than only a single maximum cell. The normalized ratio and its same-height reference are defined in section 8.2.

For comfort work, export the comparative pattern as a screening image and commission a climate-weighted assessment using the required local criteria.

17.5 Flow-section investigation

Use Visualization 4. Begin with Speed-Up, then inspect Speed, Vertical Velocity, or velocity components to answer directional questions. Use Vorticity and Q Criterion only after resolution is adequate and always record their units and range. See section 8.8 for the exact field definitions and section 8.5 for the distinction between rotational indicators and turbulence intensity.

Signed components require careful camera and coordinate interpretation. A blue vertical-velocity region means negative world Z velocity, not “cold” flow; red means positive world Z velocity, not “hot” flow.

17.6 Facade exposure comparison

Use Visualization 5 with Speed-Up for a dimensionless facade-adjacent comparison. Speed shows m/s. Pressure Proxy is suitable only as a comparative speed-derived display and must never be converted directly into structural demand; see section 8.6.

17.7 Direction series

For each wind direction:

1. keep building geometry and quality fixed;
2. change only Wind From;
3. use the same profile and domain policy;
4. orient analytical cameras consistently relative to the travel direction;
5. save Summary and a labeled view;

6. compare identical scalar ranges.

AeroField Study computes one direction at a time. Duplicate a definition branch or record each direction deliberately rather than expecting Animation Export to perform a direction sweep.

17.8 Resolution-sensitivity screen

Use Advanced Settings to compare at least two target resolutions that fit available memory. Record actual cells across, total cells, cell size, result status, and elapsed time. Check whether principal conclusions persist:

- location of high speed-up;
- passage and corner acceleration;
- wake width, height, and direction;
- facade exposure pattern;
- sign and organization of vertical or crosswind velocity;
- stability of derivative-field features.

18

Troubleshooting

Read the exact Grasshopper message first. Orange indicates a usable result with a warning or limitation; red indicates that the current operation could not produce a new result.

18.1 AeroField tab or components are missing

Confirm Rhino 8, restart Rhino completely, and inspect Grasshopper loading errors. Verify that the GHA and core DLL are together, downloaded files are allowed by the operating system, and no duplicate assembly exists.

18.2 Duplicate file conflict

Record both paths in the dialog. Quit Rhino. Keep one intended installation and remove the other. Search both Package Manager and manual Grasshopper Libraries locations. Reopen Rhino only after the duplicate is gone.

18.3 Interpreted dimensions

AeroField does not interrupt startup because a model is small. When physical scale matters, read the characteristic height, model-to-meter conversion, cell size, and solved domain in Summary and Diagnostics. Correct the Rhino document units or geometry only when those reported dimensions do not represent the intended model.

18.4 No occupied cells

The prepared building did not intersect the field as a solid. Confirm closed valid geometry, physical scale, location relative to ground, and that the intended objects are actually referenced by the Geometry parameter. Repair naked edges or invalid meshes.

18.5 Resolution exceeds Maximum Cells

The requested cells across and domain require more than the allowed field budget. Choose one deliberate response:

For a valid site with several connected buildings, leave Quality unconnected for automatic Standard. AeroField normally adapts the site grid within the selected limits and returns a field; read the achieved resolution before comparing fine wake structure.

For one tall or unusually slender building, Preview keeps the complete vertical domain and automatically returns the finest bounded field that fits its expanded preview allowance. This is a broad-flow result, not permission to ignore an under-resolved tower width. Read the achieved cells across in Summary before interpreting roof separation, narrow passages, facade exposure, or wake width. Standard and Detailed continue to stop when their required resolution cannot be represented within the selected budget.

- use Preview only for a deliberately faster broad-flow check;
- reduce unnecessary site or domain extent;
- simplify distant or tiny geometry;
- raise Maximum Cells if memory permits;
- connect Allow Resolution Relaxation=true and record the lower actual resolution.

Do not treat relaxation as invisible. Summary reports actual resolution.

18.6 Analysis plane omitted

Analysis Height lies outside the solved vertical range. Choose an in-domain height or increase Top Domain H when a larger calculated vertical extent is genuinely required. Detailed 3D Streamlines and the solved volume can remain valid even when a requested plane is unavailable.

18.7 Time or iteration limit reached

Study returned a finite field at a configured time or iteration boundary. Read Summary and Diagnostics. Preview is intentionally time-bounded and smooth. Standard or Detailed provides more field-development effort when wake width, recirculation, or smaller between-building differences matter. Check residual, mass drift, flux imbalance, repairs, and visual plausibility.

18.8 No flow paths are visible

Check that Study preview is enabled, the Rhino camera includes the clipping bounds, and the selected method normally includes paths. Zoom extents selected or use Grasshopper's preview controls. Inspect Diagnostics for generated path count and method availability. Make sure another opaque mesh is not covering the view.

18.9 Paths seem too short upstream

Method 1 uses direct calculated inlet-to-outlet traces and does not add presentation-only path extensions. If the calculated approach region needs more space, increase Upwind Domain H. This repeats the calculation and may increase the field budget, but it keeps every ordinary path physically continuous from the solver inlet.

18.10 Paths look tilted or biased

Use parallel Top and wind-source elevation views. Confirm the building is truly symmetric, Wind From is cardinal, source geometry has no hidden transforms, and the camera is aligned to world axes or wind travel. Increase Detailed Streamlines to inspect a denser subset. A systematic field bias should also appear in scalar sections, not only a sparse path selection.

18.11 Building is unexpectedly colored

Visualization 5 intentionally colors the building. In other methods, overlapping preview from source geometry or baked objects can alter appearance. Hide the original Geometry parameter preview, hide stale baked layers, and leave only Study preview visible.

18.12 A scalar field looks flat

Read the legend endpoints. A narrow field range, a fixed range much wider than the current values, large opacity, or overlapping geometry can flatten appearance. For Method 1, try Robust Global. For comparisons, keep fixed ranges and accept that low-variation alternatives may look subdued.

18.13 Movie component says Preparing

Keep the target Rhino viewport active and allow the scheduled capture to complete. Camera, display mode, dimensions, Study, or visualization changes require a new prepared set. The component is ready when its footer reports two, four, or eight Full HD frames.

18.14 Movie encoding fails

Confirm `ffmpeg` is installed and visible to a newly started Rhino process. Try MP4 first. The component reports the retained PNG frames folder, which can be encoded externally if needed.

18.15 Movie has no text or colorbar

This is intentional. All exported frames omit AeroField titles, status text, legends, colorbars, ticks, and axes. Use the live viewport for interpretation; add publication titles and legends separately when needed.

19

Performance and Responsible Use

AeroField is fastest and most useful when the model, question, resolution, and output method are chosen deliberately.

19.1 Performance priorities

The largest cost drivers are total 3D cells, field-development duration, complex geometry preparation, and detailed path generation. For responsive work:

- use Preview while editing geometry or direction;
- restrict the site to flow-relevant masses;
- avoid unresolved facade detail;
- increase Upwind Domain H only when the physical inlet region needs more space;
- change visualization methods after one Preview or Standard field is available;
- let Animation Export prepare frames before pressing Save;
- reserve Detailed for shortlisted options and sensitivity checks.

19.2 What AeroField calculates

The public Study calculates a 3D exterior velocity field and velocity-derived scalar diagnostics. It supports closed exterior masses, a solid ground, an incoming vertical speed profile, direction-specific domains, five visualization methods, baking, and fixed-field packet animation.

19.3 What AeroField does not calculate

AeroField does not currently provide:

- temperature, heat transfer, buoyancy, solar heating, or thermal comfort;
- natural ventilation through openings or interior rooms;
- pollutant, smoke, odor, moisture, or contaminant dispersion;

- validated turbulence intensity or gust statistics;
- facade pressure coefficients or structural design loads;
- climate-frequency weighting or certified pedestrian comfort categories;
- moving geometry, vegetation porosity, vehicle wakes, or terrain roughness resolved as specialist models.

19.4 When to move to specialist CFD

Commission a higher-fidelity study when decisions depend on code compliance, public safety, facade design, detailed podium or canopy flow, tall-building downwash, complex terrain, porous vegetation, thermal buoyancy, natural ventilation, dispersion, or quantitative agreement with measurements.

AeroField can improve that handoff. Export clean building geometry, state wind directions and design questions, identify suspected acceleration/wake regions, and provide comparative images showing why those areas matter.

19.5 Professional reporting

Every shared result should state geometry scope, Rhino units, wind, quality, actual resolution, result status, visualization, scalar field and range, Analysis Height where relevant, and limitations. Avoid claims such as “validated CFD,” “comfort passed,” or “facade pressure” unless supported by an independent qualified workflow.

V

APPENDICES

OpenFOAM-oriented display guidance, reporting checklists, default tables, and terminology.

20

OpenFOAM-Oriented Display Guide

AeroField and OpenFOAM are different analysis systems, but AeroField can adopt the clear visual communication practices commonly used in ParaView and professional CFD reports.

20.1 Comparable visual concepts

Table 20.1: AeroField displays and their closest common CFD visualization concepts.

AeroField	Common CFD concept	Important distinction
Detailed 3D Streamlines	Stream tracer	Same communication idea: curves tangent to velocity. Seed policy, interpolation, resolution, and solver differ.
Pedestrian Wind Map	Horizontal slice	Interpolated sample through the stored 3D field; not a separate 2D calculation.
Flow Sections	Slice/filter atlas	Bounded horizontal and vertical samples with selectable scalar fields.
Surface Exposure	Surface resampling	Samples just outside the building; not a wall-patch pressure or shear result.
Wake surface	Thresholded isosurface	Filtered wake/rotation indicator whose shape depends on threshold and resolution.
Speed-Up	Normalized speed	Dimensionless local-to-incoming speed ratio at the same height.
Pressure Proxy	Pressure-like display	Not static pressure, pressure coefficient, or load.
Vorticity	Curl magnitude	Related mathematical quantity; strongly dependent on field resolution near walls.
Q Criterion	Gradient invariant	Related visualization concept; does not imply equivalent turbulence modeling or fidelity.
Movie packets	Animated tracer overlay	Motion over fixed paths, not an unsteady pathline solution.

20.2 How to make AeroField output look more like a professional CFD plate

1. Choose one analytical question per image.

2. Use a parallel Top or elevation view for measurement-oriented figures.
3. Hide the Rhino grid, source geometry preview, and unrelated layers.
4. Keep the building neutral unless Surface Exposure is the subject.
5. Use enough streamlines to explain approach, bypass, roof flow, and wake without filling every pixel.
6. Use a fixed scalar range across alternatives.
7. Keep a visible legend in analytical still images and place field name, units, and range in the caption.
8. Use the clean movie export for motion; add titles externally.
9. State quality, actual resolution, wind, status, and limitations.

20.3 Detailed streamline composition

A professional streamline image needs three zones:

- **Approach**: coherent lines establish mean wind direction and incoming context while retaining calculated low-level variation;
- **Interaction**: lines reveal splitting, acceleration, roof lift, side passages, and near-building turning;
- **Wake**: selected lines show deficit, recirculation, and recovery without dominating the whole image.

Method 1 uses direct calculated inlet-to-outlet traces and does not append far-field geometry. Increase Upwind Domain H only when the calculation needs a longer inlet region. Keep Detailed Streamlines near 150 unless occlusion is low enough to support 170–180. Use perspective only after Top and elevation views establish analytical orientation.

20.4 Scalar presentation

For a ParaView-like scalar plate:

- use Method 3 for a single pedestrian-height plane;
- use Method 4 for vertical centerline and crosswind sections;
- use Method 5 for facade-adjacent comparison;
- set plane opacity between 0.25 and 0.45 so geometry remains readable;
- keep Color Legends on for analytical stills;
- use sequential colors for unsigned fields and diverging colors for signed fields;
- never reuse a colorbar title from another field.

20.5 What visual polish cannot change

More lines, smoother colors, a wider image, and a CFD-like palette improve communication but do not increase field resolution or validation. A more realistic result requires suitable geometry, wind profile, domain, resolution, result health, sensitivity checks, and comparison to measured or accepted benchmark evidence.

21

Study Reporting Checklist

A clear record lets another person understand what was modeled, what was displayed, and which conclusions are justified.

21.1 Minimum record

Record the following for every important study:

- project and option name;
- Rhino document units and a known measured dimension;
- included building and terrain scope;
- ground elevation policy;
- wind speed, Wind From, and travel direction;
- Power Law or Uniform profile, terrain exponent, and any absolute reference height;
- quality and every connected Advanced Settings override;
- field dimensions, total cells, cell size, and actual cells across;
- result status, elapsed time, and any warning;
- visualization method, scalar field, units, and range policy;
- Analysis Height for Methods 3 and 4;
- Upwind Domain H when the physical inlet extent differs between comparisons;
- camera projection and orientation;
- interpretation limits and next analytical step.

21.2 Comparison checklist

Before placing two images side by side, confirm:

- the same wind and profile;

- the same geometry scope outside the changed design feature;
- the same quality or actual resolution;
- the same domain policy;
- the same visualization and scalar field;
- identical color limits;
- identical Analysis Height;
- comparable camera and crop;
- equivalent result status or a clearly stated difference.

21.3 Caption examples

21.3.1 Detailed streamlines

```
AeroField Visualization 1, Standard quality.
Wind from west at 10 m/s; 150 detailed streamlines; automatic balanced upstream reach.
Colors show velocity magnitude in m/s using a robust global range.
Comparative exterior wind preview; not a code-compliance result.
```

21.3.2 Pedestrian map

```
AeroField Visualization 3, Standard quality.
Wind from south at 8 m/s; speed-up sampled 1.5 m above ground.
Fixed range 0-2: values above 1 indicate local acceleration.
Screening comparison only; no climate-frequency comfort classification.
```

21.3.3 Surface exposure

```
AeroField Visualization 5, Standard quality.
Facade-adjacent speed-up sampled outside the prepared building surface.
Comparative exposure pattern only; not facade pressure or structural load.
```

21.4 Claims to avoid

Do not label AeroField output as:

- validated engineering CFD;
- an OpenFOAM result;
- pedestrian comfort certification;

- facade pressure coefficient or design pressure;
- turbulence intensity;
- a temperature or heat-transfer calculation;
- a natural-ventilation result;
- a pollutant, smoke, or pathogen dispersion result.

22

Defaults and Accepted Values

This appendix gathers the public defaults and input ranges into compact tables for quick reference.

22.1 Study defaults

Input	Default	Accepted value
Wind Speed m/s	10	Greater than 0 and no more than 100
Wind From degrees	0	Any finite degree value, wrapped to 0–360
Analysis Height m	1.5	Nonnegative; must lie in solved height for relevant methods
Quality	Standard when unconnected	Preview, Standard, Detailed
Advanced Settings	empty	Typed Advanced Settings output
Visualization	Method 1	Buttons 1 through 5

22.2 Advanced numerical and domain controls

Input	Standard	Accepted value
Target Resolution	24	Integer 6–64
Maximum Cells	1,500,000	Integer 30,000–2,500,000
Allow Resolution Relaxation	false	Boolean
Wind Profile	Power Law	Power Law or Uniform
Wind Reference Height m	disconnected	Positive number when connected
Terrain Exponent	0.22	0–1
Ground Elevation m	inferred	Finite physical meter elevation
Upwind Domain H	5.0	At least 1; Preview uses 4.5
Downwind Domain H	5.0	At least 3
Side Domain H	1.5	At least 1
Top Domain H	1.0	At least 1

22.3 Advanced display controls

Input	Default	Accepted value
Detailed Streamlines	150	Integer 120–180
Upstream Approach H	Compatibility input	Retained for older definitions; ignored by current versions
Detailed Line Width px	1.0	0.8–3.0
Streamline Color Range	Robust Global	Robust Global, Fixed, Full Data
Fixed Color Minimum m/s	0	Finite and below maximum
Fixed Color Maximum m/s	20	Finite and above minimum
Section Field	Speed-Up	Any listed Method 4 field
Surface Field	Speed-Up	Speed-Up, Speed, Pressure Proxy
Analysis Plane Opacity	0.25	0–1
Context Line Width px	2	Integer 1–4
Viewport Labels	true	Boolean
Color Legends	true	Boolean

22.4 Movie defaults

Property	Default
Dimensions	1920 by 1080 pixels
Duration	2 seconds
Frame count	2, 4, or 8 according to capture speed
Motion	Bright packets along fixed paths
Background	White
Labels, legends, axes	Omitted
Default folder	Documents/AeroField/Movies
Default format	First available preferred local format, normally MP4

23

Glossary

Actual Resolution
Number of field cells across the resolution-driving building dimension after budget checks.

Analysis Height
Physical height above ground used for the pedestrian map and horizontal flow section.

Bake
Create persistent Rhino objects from the current Grasshopper visualization.

Characteristic Height, H
Representative building/site height used to normalize domains and display extents.

Color Legend
Scale that maps numerical values to viewport colors.

Context Path
Selected streamline included to explain flow direction around a scalar or wake visualization.

Detailed Streamline
Three-dimensional velocity-following curve selected for balanced approach, interaction, and wake composition.

Divergence
Velocity-gradient diagnostic with units of inverse seconds.

Domain
Three-dimensional region in which AeroField calculates the field.

Flow Disturbance
Absolute departure from undisturbed incoming speed; a comparative proxy, not turbulence intensity.

Flow Path
Curve following the local velocity direction; not smoke mass or concentration.

Ground Elevation
World Z level treated as the bottom solid boundary.

Major Building
Site mass large enough to influence multi-building resolution policy.

Movie Manifest
JSON record written beside movie frames with capture and study information.

Power Law
Height-dependent incoming wind-speed profile controlled by a terrain exponent.

Pressure Proxy
Comparative velocity-derived field in pascal units; not calibrated pressure or load.

Q Criterion
Velocity-gradient indicator comparing rotational and strain contributions.

Resolution-Driving Mass
Smallest significant prepared building dimension used to set cell size.

Scalar Field
One numerical value sampled at each valid field location, surface point, or section point.

Speed Deficit
Positive fraction by which local speed falls below undisturbed incoming speed.

Speed-Up
Local speed divided by undisturbed incoming speed at the same height.

Streamline
Curve everywhere tangent to the stored velocity direction at the time represented by the field.

Surface Exposure
Facade-adjacent sampling of speed-up, speed, or pressure proxy.

Upstream Approach H
Compatibility input retained for older definitions; ignored by current versions. Use Upwind Domain H to change the physical inlet extent.

Velocity Component
Signed speed along world X, Y, or Z.

Vorticity
Magnitude of local velocity curl, expressed in inverse seconds.

Wake
Downstream region influenced by blockage, speed deficit, turning, and possible reverse flow.

Wind From
Meteorological source direction; 0° arrives from north and travels south.

24

Quick Reference Cards

These pages condense the most common procedures for use beside Rhino and Grasshopper.

24.1 One-wire study

1. Reference closed building geometry.
2. Connect Geometry to Study.Buildings.
3. Start with Preview; confirm scale and wind direction.
4. Switch to Standard.
5. Click buttons 1–5 to change the view.
6. Read orange/red messages before interpreting results.

24.2 Longer physical inlet region

1. Place AeroField Advanced Settings.
2. Connect its Advanced output to Study.Advanced Settings.
3. Increase Upwind Domain H only when the solved inlet region must be longer.
4. Recalculate and review the reported cell budget.
5. Method 1 then traces directly from that physical inlet boundary.

24.3 Clean movie

1. Connect Study.Study to Animation Export.Study.
2. Set the final Rhino camera.
3. Wait for Ready: 2, 4, or 8 frames at 1080p.
4. Click Export Movie or Save As.
5. Exported frames contain no labels, colorbars, ticks, grid, or axes.
6. Read Movie Path or use the automatically opened folder.

24.4 Bake current view

1. Choose visualization 1–5.
2. Confirm scalar field and display options.
3. Click Bake View to Rhino.
4. Disable Grasshopper preview.
5. Organize and render the persistent Rhino curves and meshes.

24.5 Before sharing

State wind, quality, actual resolution, result status, visualization, scalar field, units, range, Analysis Height, and limitations. Keep alternatives on the same analytical basis.

Index

See the flow.
Compare the design.
State the limits.

AeroField helps turn a building mass and a wind assumption into a clear, inspectable design conversation.

AeroField

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