

# 3D Tree

An Alternative Visualization Approach for Complex Data



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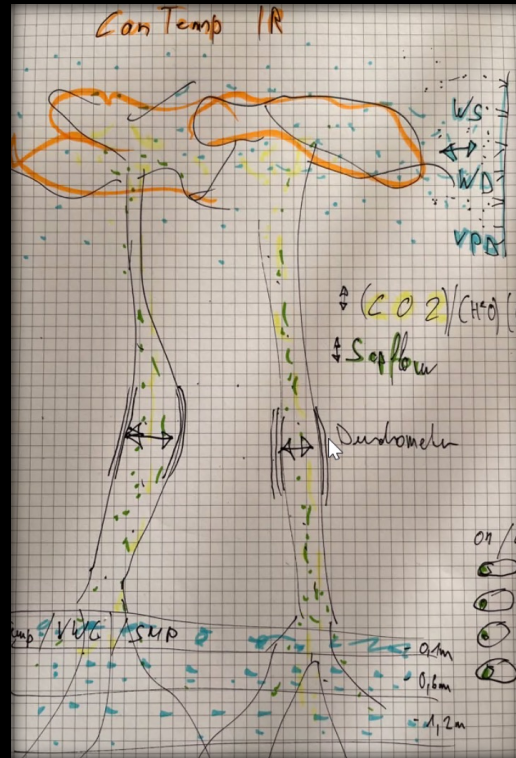


# Data Visualization Pfywald

How can we visualize the complex interaction between forest, soil, and atmosphere to the general public?

What level of detail can be implemented / what makes it get to complex?

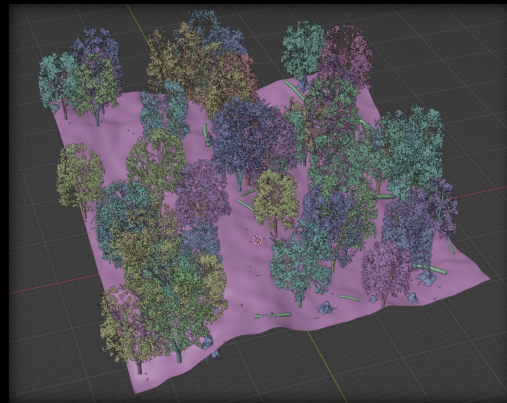
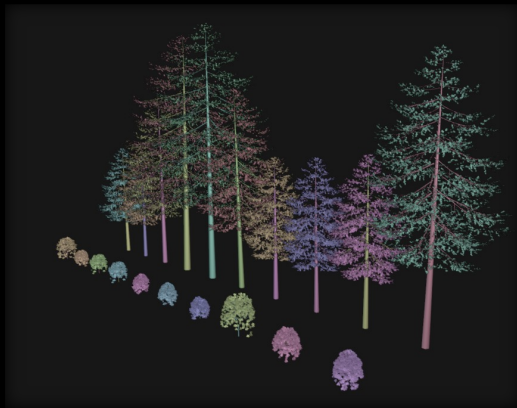
# Data Visualization Pfywald



Sketch by Jonas Gisler of the setup.



# Data Visualization Pfywald



# Data Visualization Pfywald

Step 1:  
Create Tree Model



Photographs of some individual trees in



Pfywald, provided by Marcus Schaub.



# Data Visualization Pfywald

Step 1:  
Create Tree Model





Settings: Branch Splitting

Branch Splitting:

Levels	4		
Base Splits	0		
Split Height	0.20	Split Bias	0.00
Start Length:	0.20		0.25

Branch Distribution

Branch Distribution	3.00
Whorls	50

Branches:

0	0.00
50	0.30
10	0.40
10	0.00

Segment Splits:

0.00
5.00
0.00
0.00

Split Angle:

0.00	0.00
44.00	5.00
50.00	0.00
0.00	0.00

Split Angle Variation:

0.00	0.00
15.00	0.00
0.00	0.00
0.00	0.00

Rotate Angle:

99.50	15.00
137.50	0.00
-90.00	0.00
137.50	0.00

Rotate Angle Variation:

0.00	0.00
20.00	0.00
33.33	0.00
0.00	0.00

Branch Attachment:

Alternate **Opposite** Rotate

Split relative to le... Split Straigh 0.50 Split Length 0.00

Curve Resolution:

10
5
3
1

Settings: Branch Growth

Branch Growth:

Shape: Custom Shape Tapered Cylindrical

Custom Shape:

0.10	0.60	0.70	0.40
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Length:

1.00	0.00
0.33	0.15
0.75	0.25
0.45	0.00

Length Variation:

0.00	0.00
12.50	0.00
20.00	0.00
33.33	0.00

Down Angle:

90.00	0.00
110.00	42.00
45.00	10.00
45.00	10.00

Down Angle Variation:

0.00	0.00
20.00	0.00
33.33	0.00
0.00	0.00

Curvature:

0.00	12.50
40.00	20.00
30.00	33.33
0.00	0.00

Curvature Variation:

0.00	0.00
2.00	0.00
0.00	0.00
0.50	0.50

Outward Attraction:

0.00	2.00
0.00	0.00
0.00	0.50
0.00	0.50

Vertical Attraction:

0.00	0.00
0.50	0.50
0.00	0.50
0.00	0.50

Use parent angle

# Data Visualization Pfywald

Step 1:  
Create Tree Model

Blender – “Sapling Tree Gen” Tool <sup>1</sup>

Settings: Branch Radius

Branch Radius:

Bevel Bevel Resolutio 2

Ratio 0.01

Minimum Radius 0.002

Close Tip

Root Flare 1.25

Split Radius Ratio 0.00

Other:

Auto Taper  No branch at ste...

Radius Scal 1.00 Radius Scal 0.10

Radius Ratio Power 1.00

Taper:

1.00	1.00
1.00	1.00
1.00	1.00
1.00	1.00

Tweak Radius:

1.00	1.00
1.00	1.00
1.00	1.00
1.00	1.00

Settings: Geometry

Geometry:

Bevel  Make Mesh

Bevel Resolutio 2 Curve Resolutio 4

Handle Ty... Auto

Mater... 0 0 0 0

Random Seed 0

Tree Scale:

Scale 17.00 Scale Variat 1.00

Prese... Export Preset

Overwrite

Load Preset  Limit Import

[1]: Andrew Hale et al. [Blender Documentation](#)

# Data Visualization Pfywald

Step 1:  
Create Tree Model

Blender – “Sapling Tree Gen” Tool<sup>1</sup>





# Data Visualization Pfywald

Step 1:  
Create Tree Model

Step 2:  
Extract Curves from Tree Object



- >> Hierarchically structured bezier curves
- >> Extract points along the curve
- >> Connect start point of branch to closest point in parent
- >> Generate a graph network by connecting the neighbouring points

# Data Visualization Pfynwald

Step 1:  
Create Tree Model

Step 2:  
Extract Curves from Tree Object

Step 3:  
Find Endpoints of Curves



>> List all points at the end of a branch

>> Mark the point that connects the tree to the ground

>> Looping through the graph from endpoint to groundpoint or otherwise



# Data Visualization Pfywald

Step 1:  
Create Tree Model

Step 2:  
Extract Curves from Tree Object

Step 3:  
Find Endpoints of Curves



# Data Visualization Pfynewald

Step 1:  
Create Tree Model

Step 2:  
Extract Curves from Tree Object

Step 3:  
Find Endpoints of Curves

Step 4:  
Connect to Real World Data



>> VPD values on three level with 4 - 5 sensors each

>> Interpolate between 3 nearest neighbours for each endpoint

# Data Visualization Pfywwald

Step 1:  
Create Tree Model

Step 2:  
Extract Curves from Tree Object

Step 3:  
Find Endpoints of Curves

Step 4:  
Connect to Real World Data

Step 5:  
Simulation of Photosynthesis, Respiration and Transpiration

>> Simulation for the **visualization** of stomatal gas exchange

>> **Not** to get numerical accurate consumption or production values





# Data Visualization Pfywald

## Step 5:

### Simulation of Photosynthesis, Respiration and Transpiration

>> Simulation for the **visualization** of stomatal gas exchange

>> **Not** to get numerical accurate consumption or production values

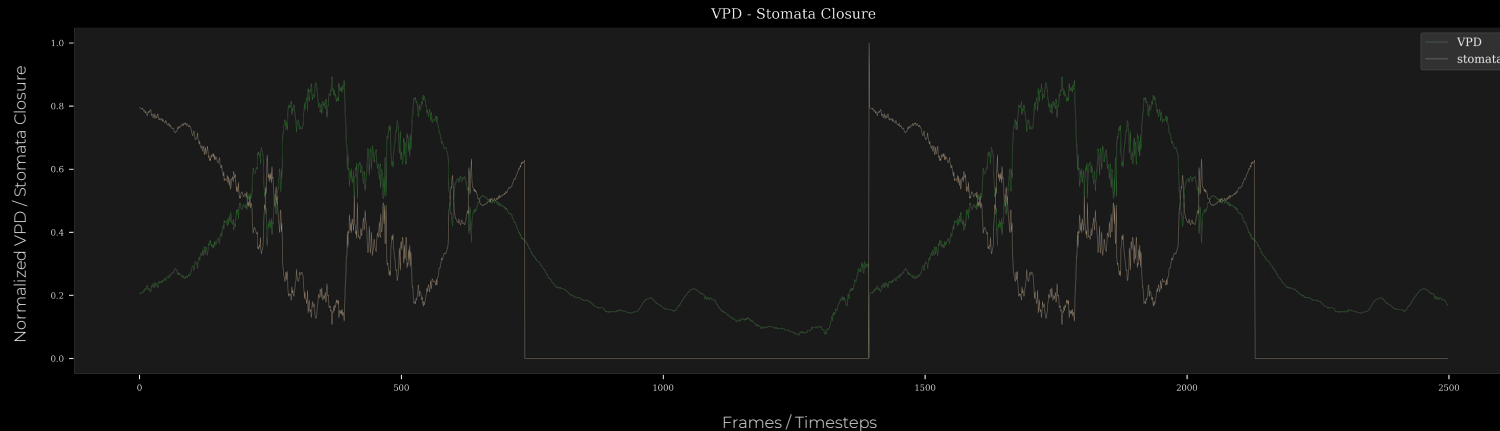
Real World Data

>> VPD – Vapour Pressure Deficit

> Temperatur (air & canopy), relative humidity

>  $VPD = \text{saturated\_vapour\_pressure} * (1 - \text{relative\_humidity}/100)$

>> Day/Night





# Data Visualization Pfywald

## Step 5:

### Simulation of Photosynthesis, Respiration and Transpiration

>> Simulation for the **visualization** of stomatal gas exchange

>> **Not** to get numerical accurate consumption or production values

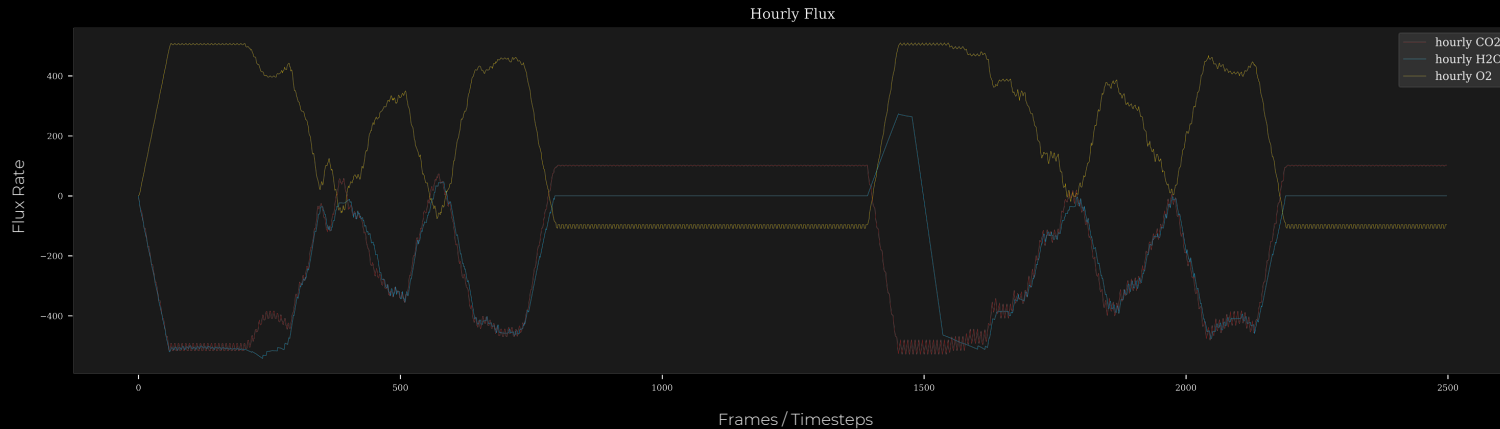
### Simulated Data

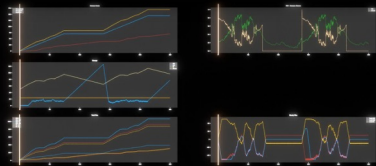
>> Internal storage (CO<sub>2</sub>, O<sub>2</sub>, H<sub>2</sub>O, Glucose)

>> Stomata Closure & Calvin cycle approximated based on VPD-readings and light

>> Stomata Closure

> To what extend is gas exchange possible





# Data Visualization Pfywald

Step 5:

Simulation of Photosynthesis, Respiration and Transpiration

>> Simulation for the **visualization** of stomatal gas exchange

>> **Not** to get numerical accurate consumption or production values

Photosynthesis or Photorespiration?

>> Each endnode gets assigned n – cores

> 10 „cores“ for Photosynthesis or Photorespiration during the day

> 2 „cores“ for Respiration during the night

--> Approximately 10'000 „decisions“ each frame

>> „Speed“ currently constant

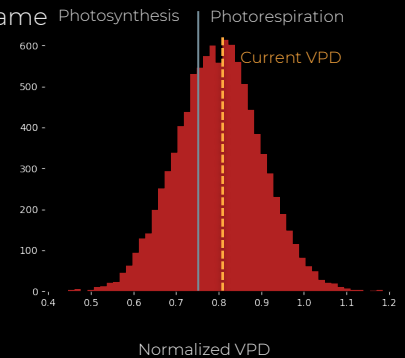
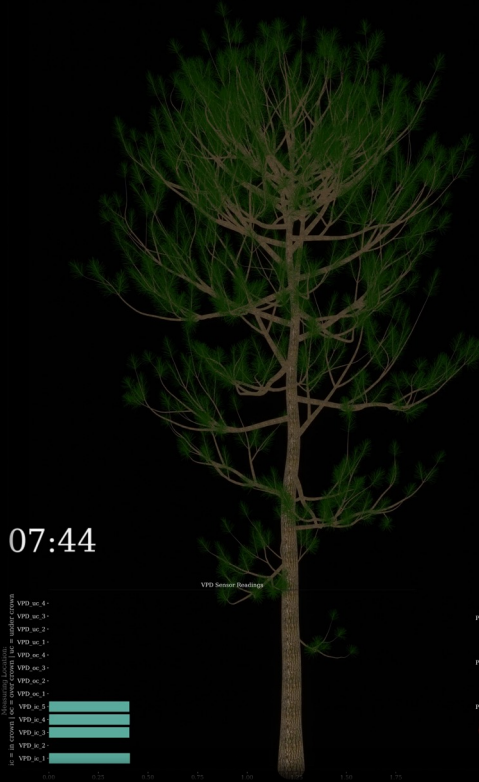
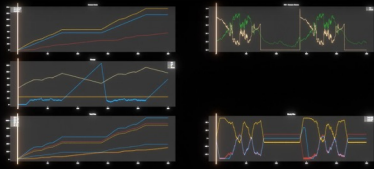


Fig 1: n (10000) normal distributed values (mean = 0.8, std = 0.2)





# Data Visualization Pfywald

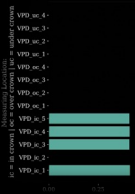
Step 5:

Simulation of Photosynthesis, Respiration and Transpiration

- >> Simulation for the **visualization** of stomatal gas exchange
- >> **Not** to get numerical accurate consumption or production values
- >> Transpiration while the stomata is open
- >> O<sub>2</sub> & CO<sub>2</sub> exchange rate based on opening level of stomate
- >> surplus & shortage
- >> H<sub>2</sub>O atm not limited
  - > Soil moisture values should be integrated in the future



07:44



08-18

03:19

Control

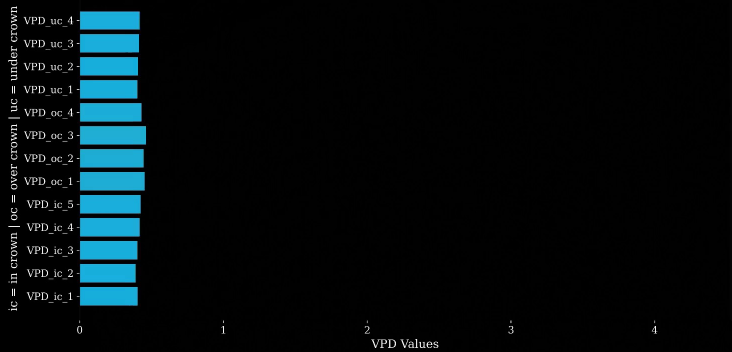
Treatment

Molecule Exchange Leaf to Atmosphere

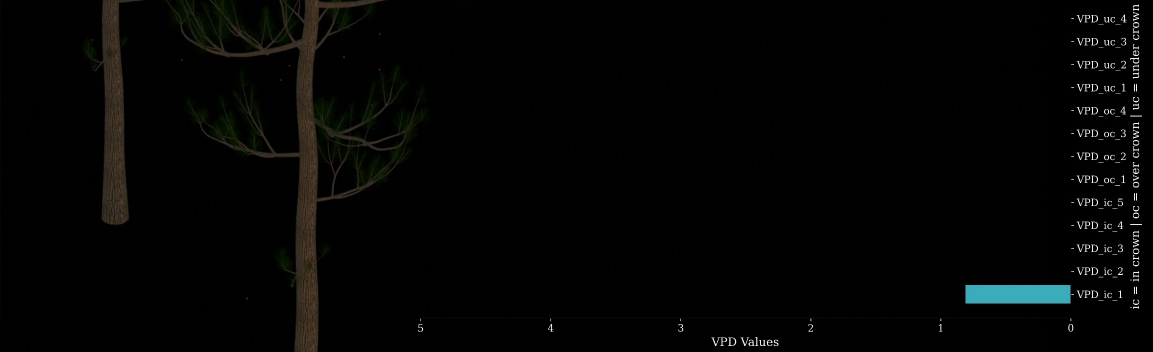
- O<sub>2</sub>
- H<sub>2</sub>O
- CO<sub>2</sub>

Treatment

VPD Sensor Readings



VPD Sensor Readings



Control

08-18

03:19

Control

Treatment

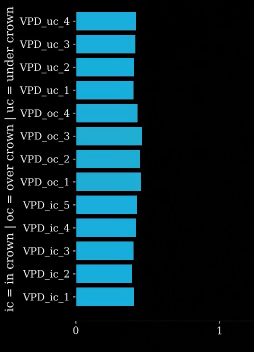
Molecule Exchange Leaf to Atmosphere

- O<sub>2</sub>
- H<sub>2</sub>O
- CO<sub>2</sub>



Treatment

VPD Sensor Readings



VPD Sensor Readings

Control





# Outlook

Integrate Soil Moisture - Additional Internal Flux Visualization

Refine Cycles - Make the Simulation adjust Parameters on the go

Close to Real Time Update on the Website