



REpower Systems AG:
Forest Modeling
- Validation and Further Development

David Hilbert

WindSim User Meeting

16 June 2011



What is this presentation about?



- Work in progress – at starting point
 - Presentation of project plan
 - Feedback much appreciated!



Motivation: Forest Modeling



Status of Forest Modeling in WindSim



Project Setup



Discussion

Why work on forest modeling in CFD?

- Forested sites become ever more frequent
 - e.g. European average forest coverage: 35-45%



- WAsP fails more or less if it comes to forest, particularly in complex terrain
- Problem: WindSim doesn't perform too well, either...

Wind profile in forest



- Decrease in wind speed (momentum)
 - Increased shear
- Turbulence generated and absorbed
 - Large eddies get broken into smaller ones
 - Tree movement induces additional small eddies
- Recirculation occurs even at lower slopes



Motivation: Forest Modeling



Status of Forest Modeling in WindSim



Project Setup



Discussion

Phenomena addressed:

- Decrease in wind speed (momentum)
 - Increased shear

- (recirculation)

?
✖

Details for roughness height 1.6 properties:

Roughness height	1.6
Forest height	200
Forest porosity	0
Forest resistive force const. C1	0
Forest resistive force const. C2	0
Forest cell count in Z direction	22

Forest cell count in Z direction

The number of cells in the vertical direction to use for modeling the forest

OK

Cancel

Measures taken:

- Introduction of roughness-based canopy layer with
 - Porosity
 - Momentum sink (drag forces):
 - $\sim U$
 - $\sim U^2$

$$\rho U_i \frac{\partial U_j}{\partial x_i} = \frac{\partial}{\partial x_i} \left[\mu_t \frac{\partial U_j}{\partial x_i} \right] - \frac{\partial P}{\partial x_j} + \rho f_j + S_j \quad [\text{N/m}^3]$$

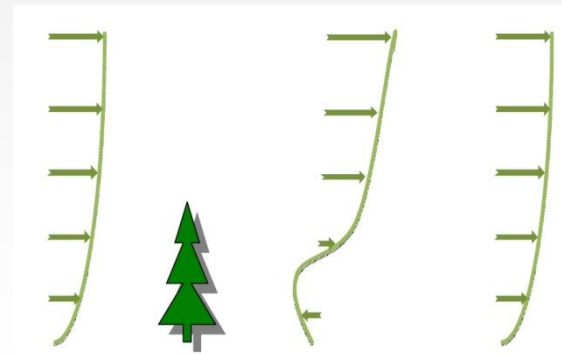
$$S_j = -\rho C1 U_j - \rho C2 \sqrt{U_i U_i} U_j \quad [\text{N/m}^3]$$

Drawbacks / Shortcomings

- Forest effect on turbulence is not accounted for!



- Momentum drag: Porosity, C_1 , C_2 , ...
 - Too many parameters (?)



- → Consequence: a dependable application of the WindSim forest model cannot be guaranteed

Validation

Extensive validation

- Standard publications: just one/two sites
 - 6-10 sites, range of complexity and forest type
 - One detailed setup, others with „best practice“ approach

If time allows...

- Stability
- Turbulence models
- Boundary conditions
- ...

Further Development

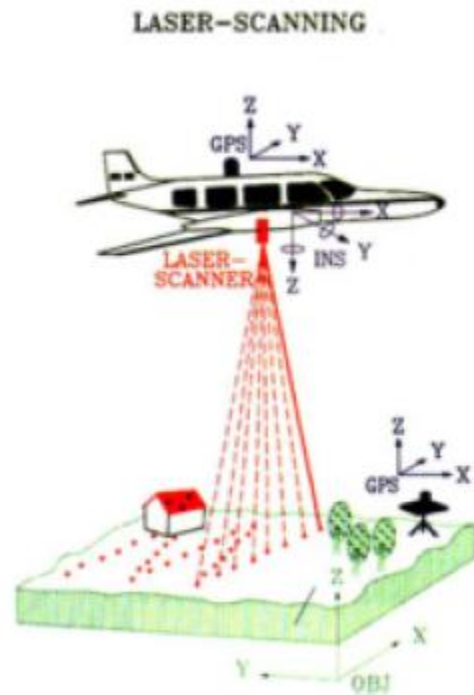
Model improvements

- Take into account effect on turbulence
- Further approaches?
- ...?

Practical application

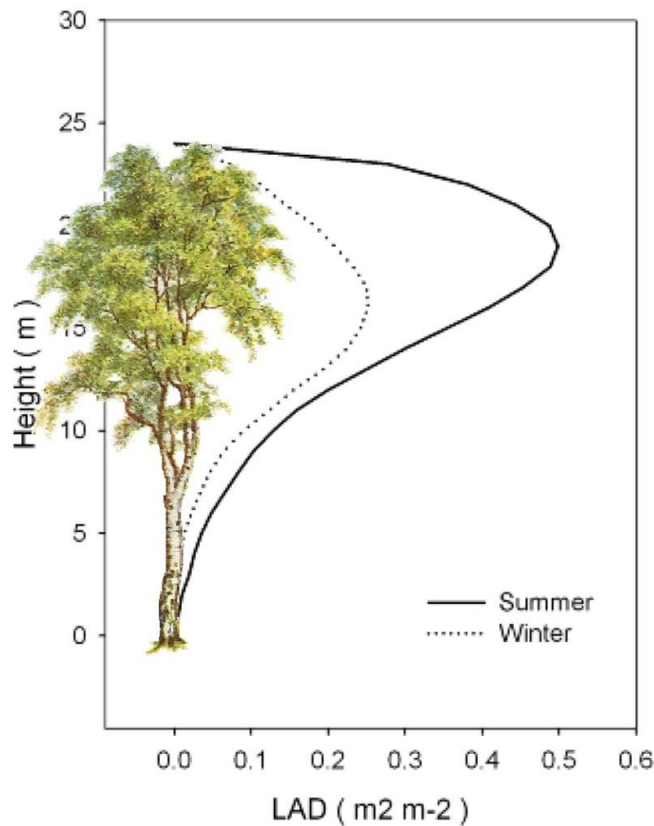
- Simplification of settings
- Develop guidelines for parameter settings
- ...?

Quality of data input



- Map quality (forest extension)
- Forest info quality
 - Height
 - Type of tree (→ LAD?)
 - Local distribution
 - ...

Forest properties vary!



- Variation in space
 - Homogeneous forest doesn't exist
 - Horizontally
 - Vertically
- Variation over time
 - Leaf area density
 - Tree height (managed forests!)

Influence of non-forest modeling parameters

- Stability may play an important role

- Choice of
 - Turbulence model
 - Boundary conditions

Validation

- Cross-predictions not sufficient!
- VDI Guideline...
- Best practice from Meteorological Institute, University of Hamburg



© REpower Systems AG

All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photography, recording, or any information storage and retrieval system, without permission from REpower Systems AG.