

Winds and forests - general recommendations for using WAsP

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Contents

- Overview of measurements
- Turbines/masts *in* a forest
- Turbines/masts *outside* a forest
- Scary story!!
- Conclusions



Measurements

- Beech forest (Sorø):
Characteristics: *25m tall,*
roughness 1.6-2m,
displacement height 20m.
Measurement series: *1996- 2009*
- Pine forest (Ulfborg)
Characteristics: *18m tall,*
roughness around 1 m
Measurement series: *1996-*
- Several shorter campaigns near or in forests.



Turbines in a forest

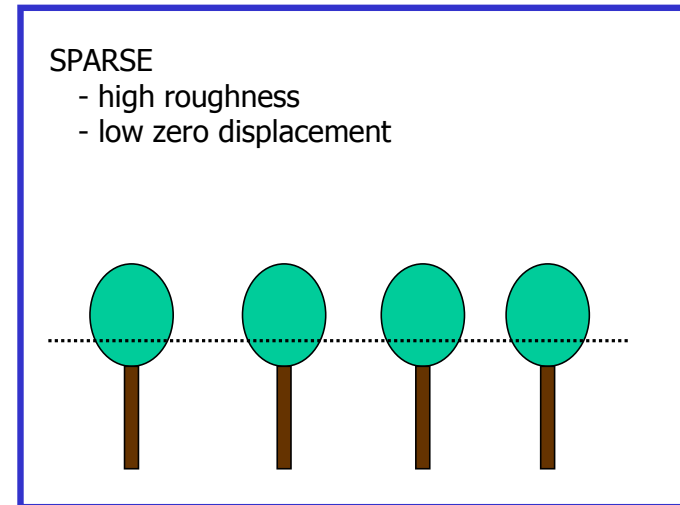
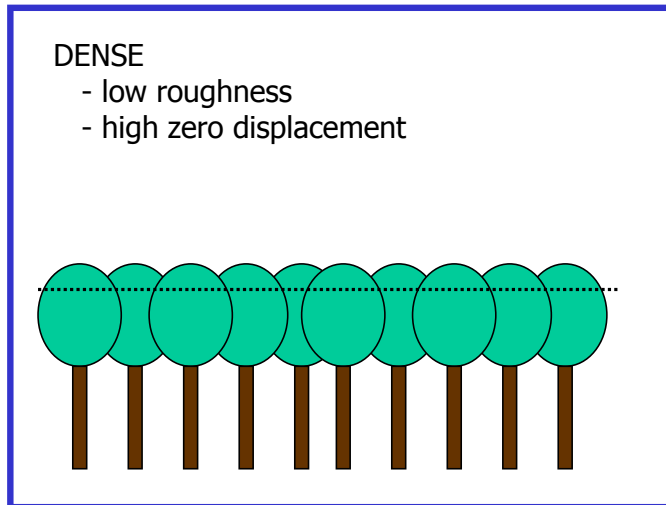
- Roughness length and zero-displacement height
- The roughness sublayer
- Using WAsP – when and why does it work?



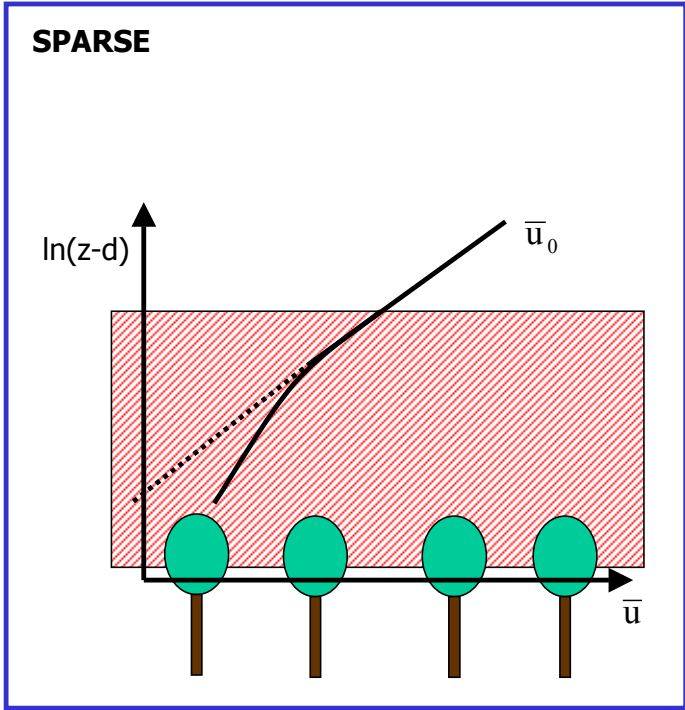
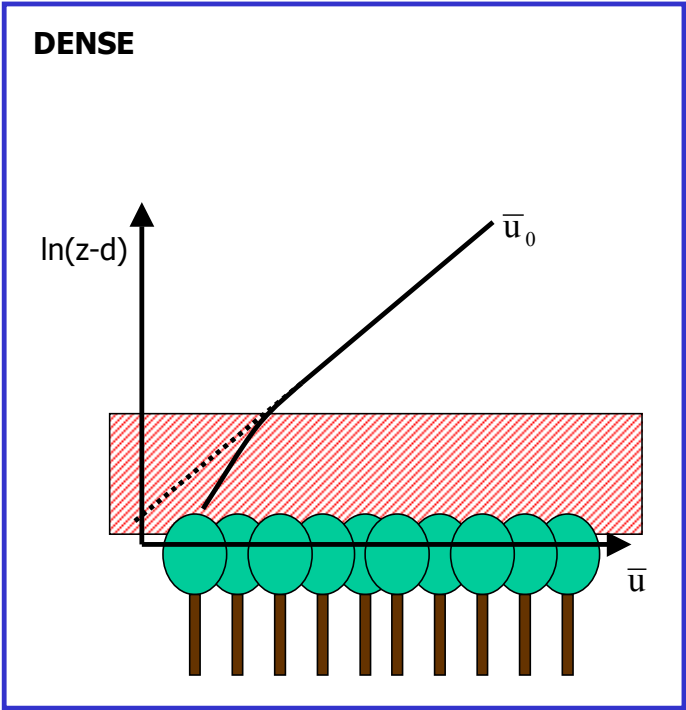
Roughness and zero displacement height

Depends on

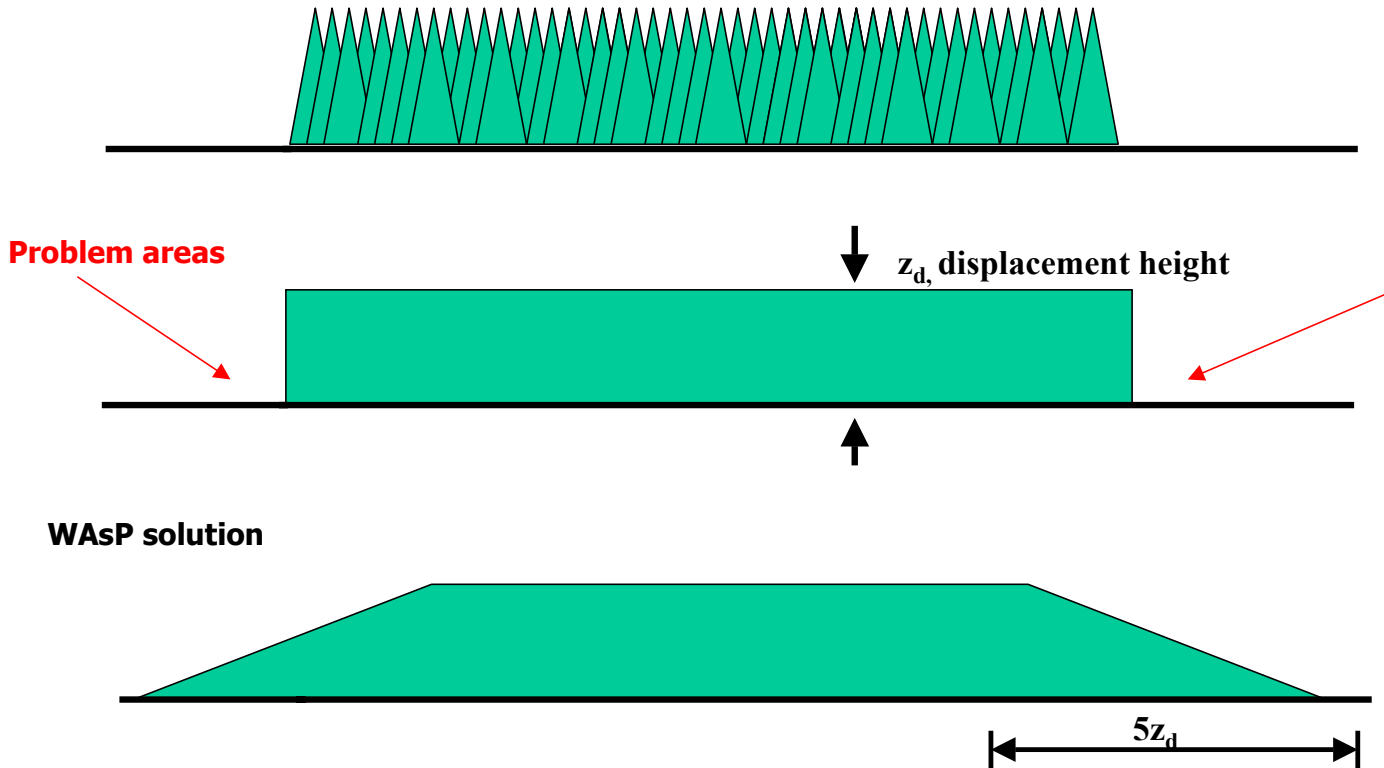
- The mean height of the roughness elements (trees)
- The density of the forest



The roughness sub-layer effect



Forest edge effects – displacement height

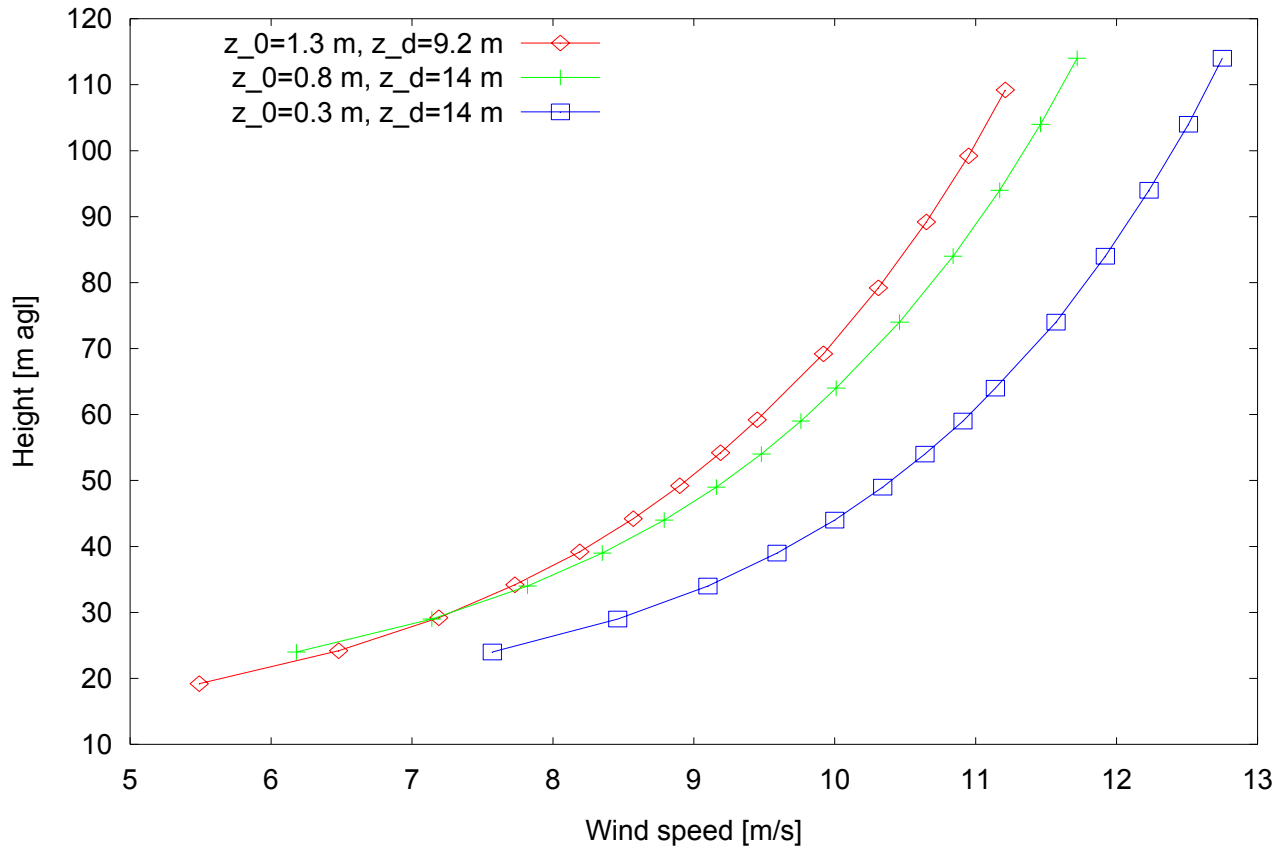


Running WAsP in the forest

- Add roughness and zero displacement height as a function of tree density (Raupach, 1992, 1994, 1995; Verhoef et al, 1997).
- Smooth forest edges over five displacement heights
- WAsP assumes no roughness sublayer (=> underestimation of the wind speed), i.e. be careful with results for sparse forests!



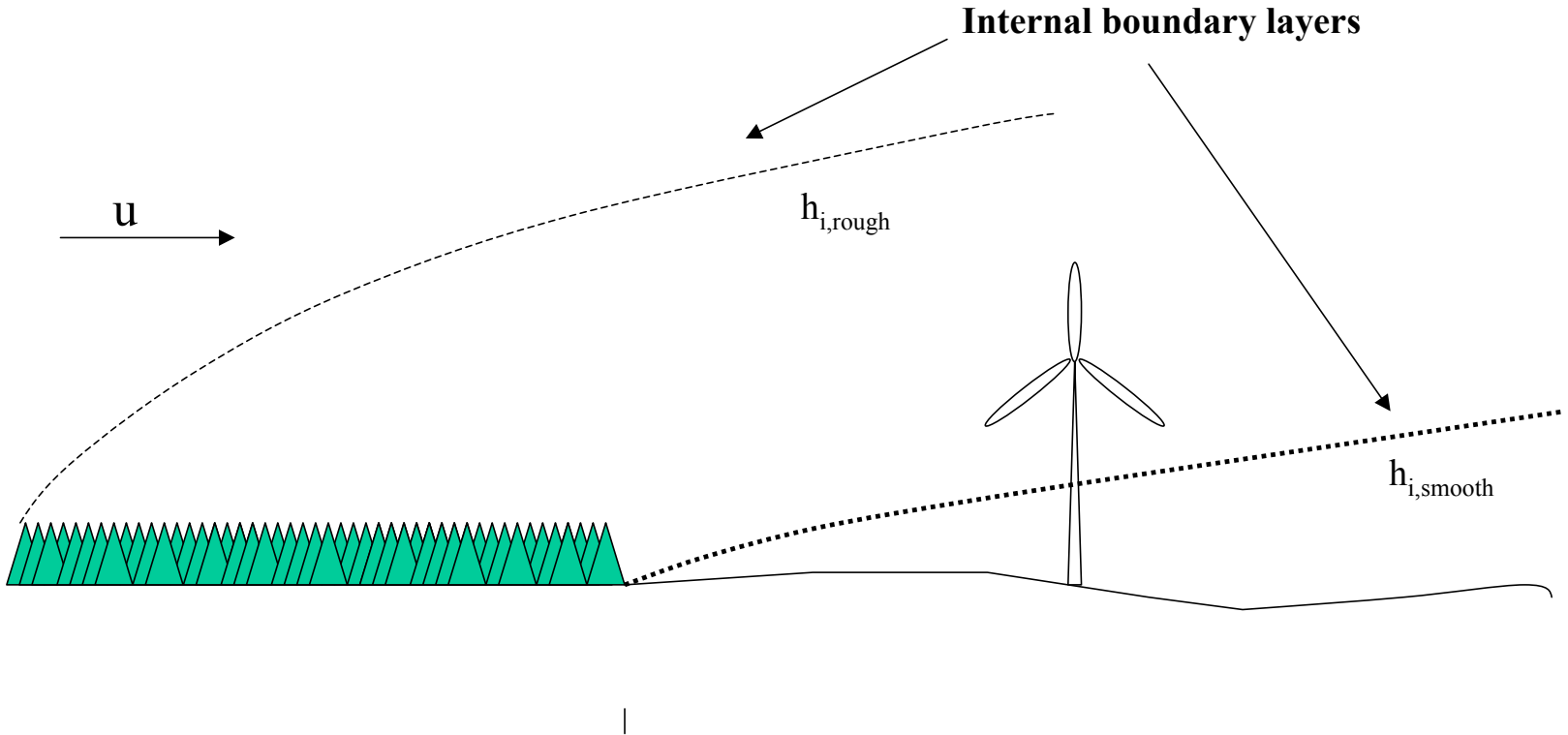
WAsP results for two dense and one sparse forest



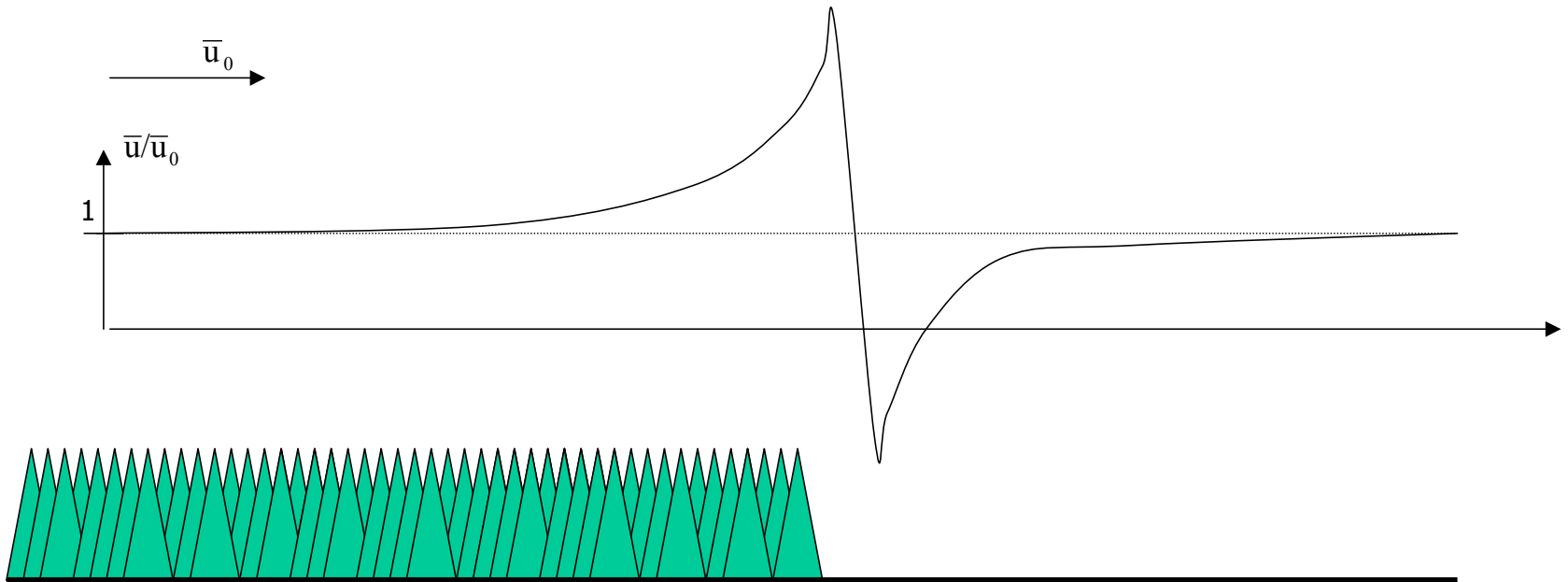
Flow near a forest

- Roughness
- Zero-displacement height leads to orographic effects
- Using WAsP

Wind turbine near (behind) a forest



Orographic effects of forest edge

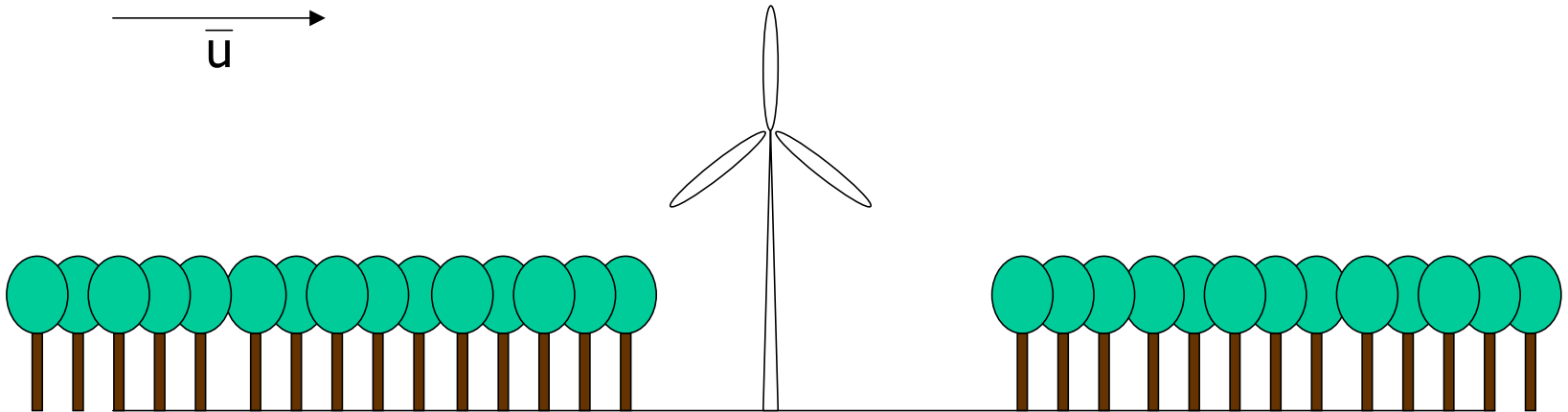


Using WAsP near a forest

- Add displacement height and roughness as a function of tree density (Raupach, 1992, 1994, 1995; Verhoef et al., 1997)
- Smooth edges over 5 displacement heights
- Do not trust results very close to forest edge

Scary story – turbines in clearings

- high roughness, no effect of clearing
- orographic effect leads to a reduction in wind
- edge effects may cause a very turbulent environment



Conclusions

- For wind engineering purposes, forest influence should if possible be avoided!
- WAsP results can so far only be trusted for dense forests. For sparse forests, WAsP is likely to underestimate the wind speed due to the roughness sublayer.
- Roughness and displacement height are dependent on tree density, expressions exist.
- When using WAsP near a forest, displacement height and edge smoothing should be added.
- Wind turbines in forest clearings is generally a very bad idea!
- Future versions of WAsP will include features typical for forest.