

### The latest news about ... ...How to get forest height data for wind modeling..

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Data from airborne lidar 18m tall trees

Wind Denmark, Herning, October 2019

#### The effects of the trees on the wind depend on tree dimensions and tree density



Raupach 1994: Simplified expressions for vegetation roughness length and zero-plane displacement as functions of canopy height and area index *Boundary-Layer Meteorology*, **71**: 211-216.

#### From forest to model parameterization

Displacement height and surface roughness for roughness models: WAsP, WRF, WENG, CFD et c Forest parameters in models with a distributed drag force parameterization: CFD, Orfeus etc



Raupach 1994: Simplified expressions for vegetation roughness length and zeroplane displacement as functions of canopy height and area index *Boundary-Layer Meteorology*, **71**: 211-216.

#### The old way "land use to roughness"... includes no information on either tree height or density



Floors, R., Enevoldsen, P., Davis, N., Arnqvist, J., and Dellwik, E.: From lidar scans to roughness maps for wind resource modelling in forested areas, Wind Energ. Sci., 3, 353–370, https://doi.org/10.5194/wes-3-353-2018, 2018.

# Tree height information from airborne lidar scans "ORA" method



## ORA outperformed the existing land use class translations



Floors, R., Enevoldsen, P., Davis, N., Arnqvist, J., and Dellwik, E.: From lidar scans to roughness maps for wind resource modelling in forested areas, Wind Energ. Sci., 3, 353–370, https://doi.org/10.5194/wes-3-353-2018, 2018.

Land use products have global coverage.

### ... Airborne lidars are increasingly available, but coverage is far from global ...

... But what can we get from satellites?

#### Recent satellite launches



Launch June 2015 and March 2017







Launched September 15, 2018 First version of data released. Next update comes in a month.





Launched December 5th 2018, No data released yet, but this example shown on home page.







### The interferometric coherence shows a dependence on the tree height



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#### Using data fusion and machine learning to predict forest height







- Optical and RADAR satellite imagery
- Canopy height data from ICESat-2
- Machine learning for modelling and predicting forest heights





#### Northern Sweden: airborne lidar















Terrain height, 20m resolution





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#### What I haven't talked about at all...



Wind farms in forests face highly variable wind conditions due to the diurnal cycle and large-scale temperature effects.

Wind conditions for the lower part of the rotor cannot be safely extrapolated to the upper part of the rotor.

#### Conclusion: The future forest height information can (likely) be found from space



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#### Thanks for listening!





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