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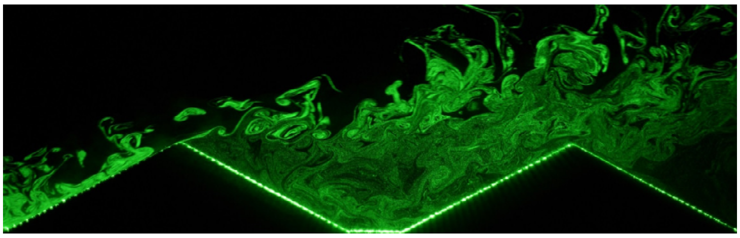
Technical Meteorology

Experimental investigation of complex terrain effects on wind dynamics within the lower atmosphere



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introduction

- complex terrain (CT): irregular orography with influence on local meteorology (NWP accuracy)
- surface heterogeneities more evident with increases in numerical modelling capabilities

project

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to what extent do terrain features/surface heterogeneities influence near-ground turbulence?

- limits of influence upwind/downwind from terrain
- effects of individual geometric parameters
- feasibility of classifying orographic structures
- validation data for numerical CT flow modelling
- study domains: sub-mesoscale/microscale real/**idealised** **single**/grouped terrain features

real vs. idealised terrain

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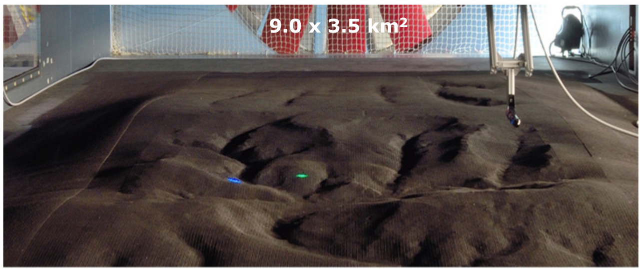
- sub-mesoscale region Hainich National Park (Germany) at 1/1750: issues with turbulence measurements



- LES validation experiments require simple geometries & small domains (Kempf, 2008)

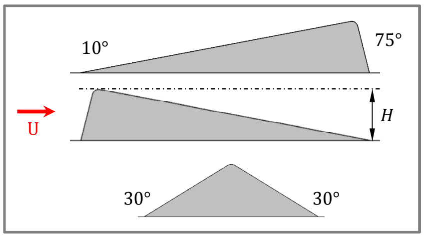
Kempf (2008). *LES validation from experiments*. Flow Turbulence Combust 80, 351-373

idealised features

- microscale idealised single terrain features: 2 campaigns
- approximate model scale: 1/1000

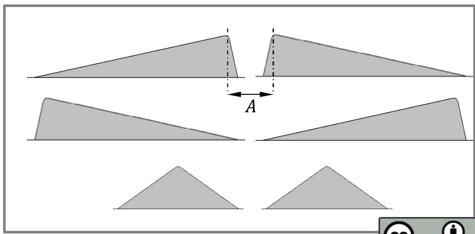
3D ridges

- 3 distinct slopes and 2 heights ($H = 80$ & $200\ mm$)
- total of 4 models



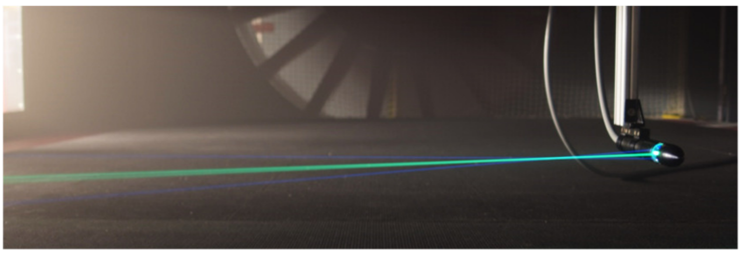
3D valleys

- from ridges ($h_{ms} = 80\ mm$)
- 3 types with systematic variation of width (A)
- total of 13 models



experiments

- WOTAN (18 x 4 x 2.75-3.25 m) following VDI 3783-12 & measurements with 2D LDV (high resolution)
- idealised, neutrally stratified flow (focus on ASL)
- flat terrain with homogeneous roughness as reference (terrain-following coordinates)



VDI 3783-12 (2000). *Physical modelling of flow and dispersion processes in the atmospheric boundary layer – Application of wind tunnels*

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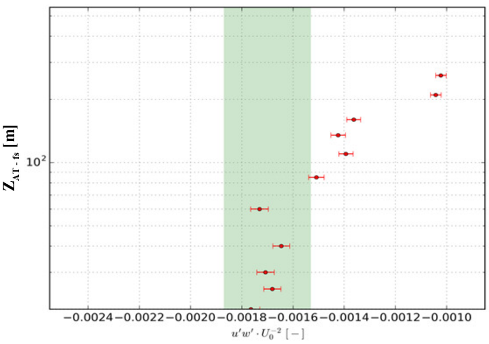
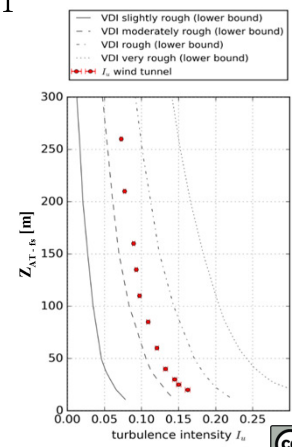
modelled inflow

- Reynolds number independent and fully turbulent ABL flow
- moderately rough ASL: $z_{0,FS} = 0.10 \pm 0.01\ (m)$

  $\alpha = 0.13 \pm 0.01$
- $h_{ASL,FS} \approx 100\ m\ (H_{ABL,FS} \approx 1000\ m)$





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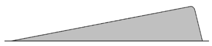
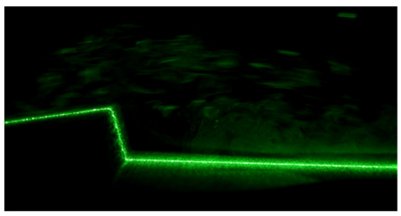
flow over ridges I

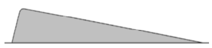
Non-symmetric with smooth windward slope



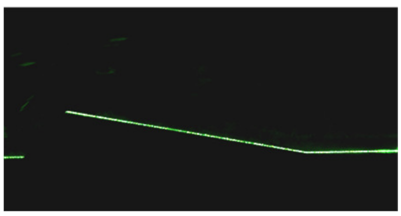
$t_{scale} = 1/1000$



Non-symmetric with steep windward slope



$t_{scale} = 1/1000$



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flow over ridges II

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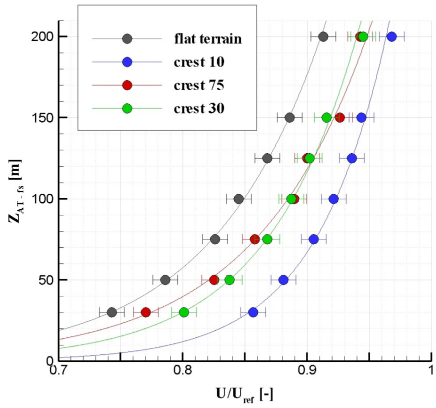
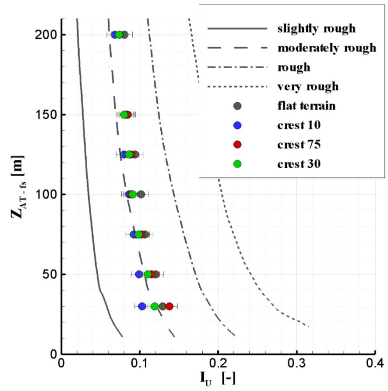
mean flow at crest





- speed-up (wind energy)
- variability of I_U at lowest heights

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flow over ridges III

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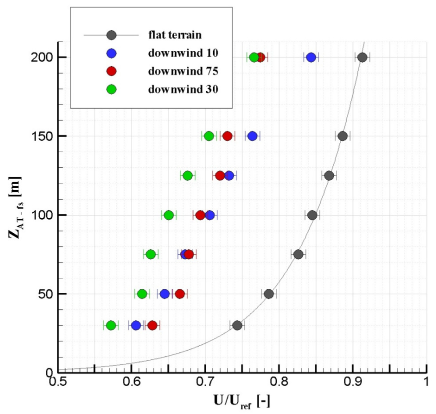
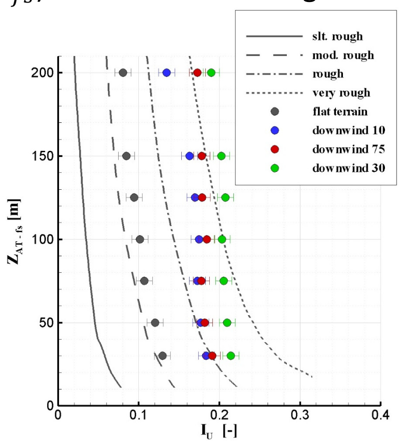
mean flow $23H$ ($\approx 1850\ m_{fs}$) downwind from ridge





- terrain still affects the flow
- high I_U (different roughness classes)

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flow over ridges IV

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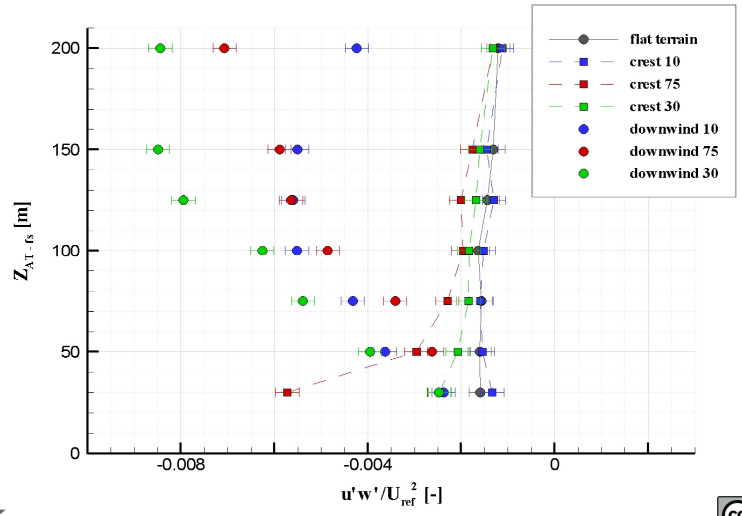
mean vertical turbulent fluxes: crest vs. downwind



flow over valleys

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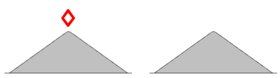
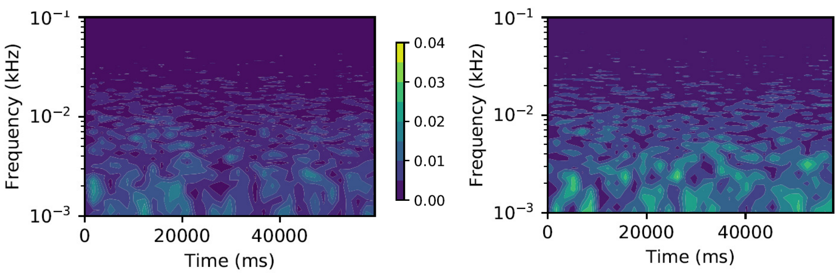
JTF (FFT) u': flat Vs. crest of ridge 1 (@ $Z_{AT_{fs}} = 50\ m$)





gustiness, intermittency
directional fluctuations
} terrain effects

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conclusions

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- CT affects low-altitude turbulence (vs. flat terrain with homogeneous roughness)
- data quality & transient data analyses are ongoing
- qualified validation data to be uploaded at EWTL's CEDVAL-LES database

Workshop Feb/March 2019 (no fee)

Project dissemination and discussion for experimentalists and numerical modellers dealing with complex terrain flows

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