The influence of a forest parameterization and landuse data on the simulation of boundary layer flows over complex terrain

J. Wagner, N. Wildmann, T. Gerz, A. Schady, K. Elsen

Institut für Physik der Atmosphäre
DLR Oberpfaffenhofen

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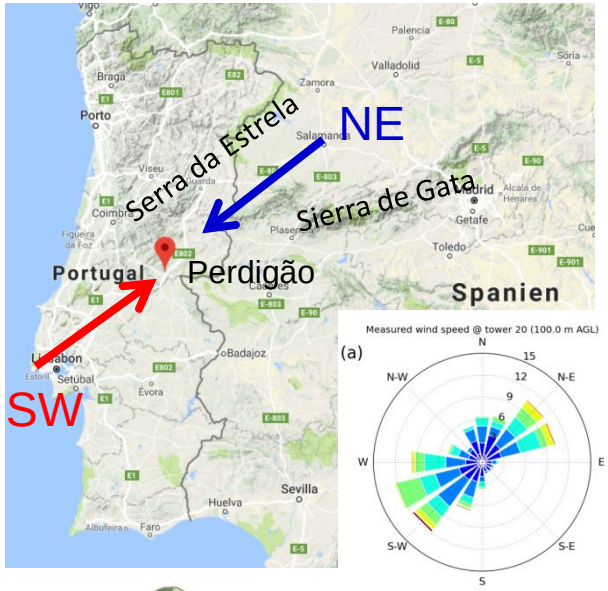
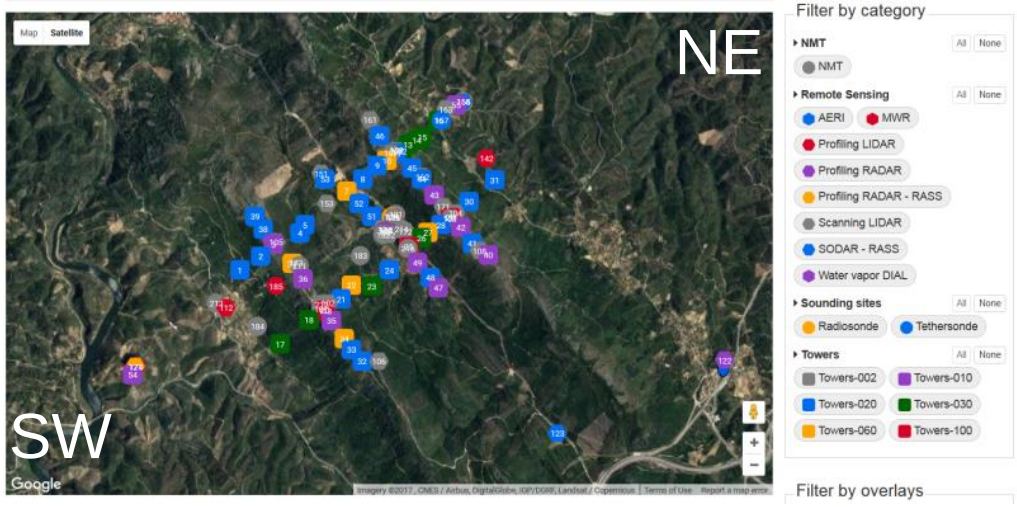
DLR

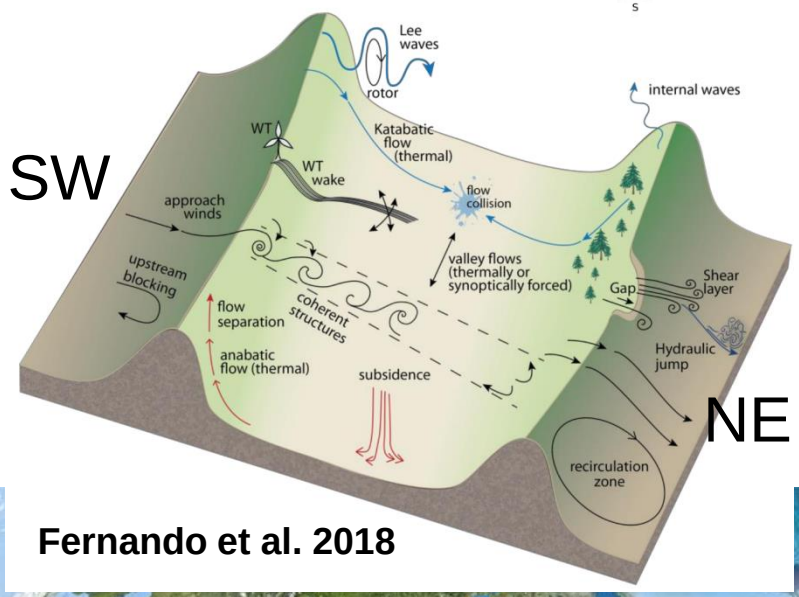
Perdigão campaign 2017

PERDIGÃO
Field experiment

- **Boundary layer flow (ABL)** over complex terrain
- Interaction with **wind turbine (WT)**
- Parallel **double ridge** (1.4km distance, 200m depth)
- More than 20 research teams from Europe and US
- **Instrumentation**: 40 meteorological towers, 180 anemometers, 28 lidars, MWR, radiosondes, sodar, rass, windprofiler, microphones
- **IOP**: 1. Mai – 15. Juni 2017



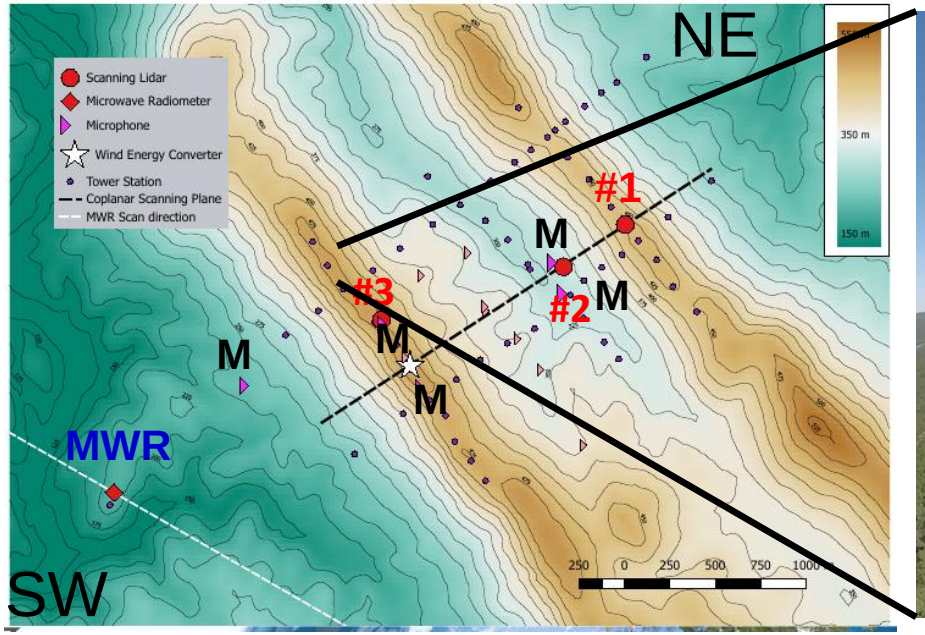




Fernando et al. 2018

DLR

DLR instrumentation



3 **Doppler lidars**
=> Measurement of **wake**

MWR Profiler
=> Measurement of stratification

5 **Microphones**
=> Sound propagation in the valley

Perdigão WT (Enercon 2MW):

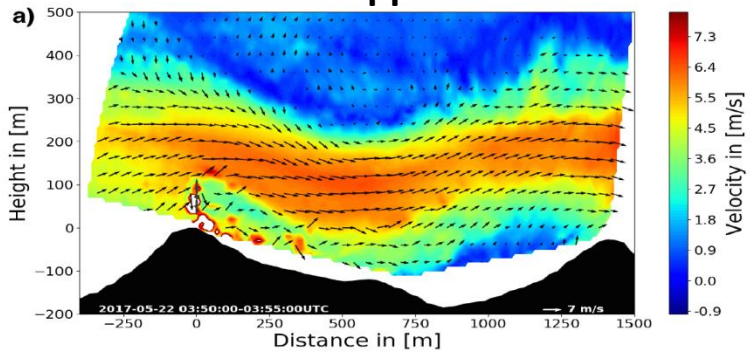
- Hub height: 78 m
- Rotor diameter: 82 m

Perdigão Topography:

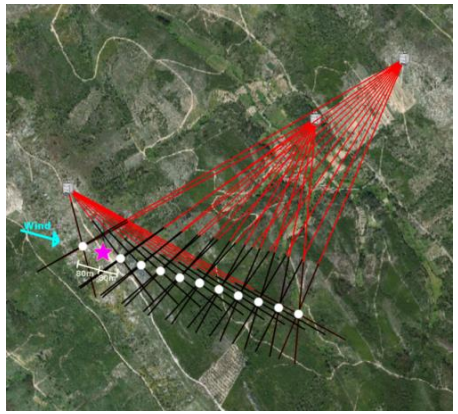
- Hill distance: 1.4 km
- Valley depth: 200 m

Measurements: see poster

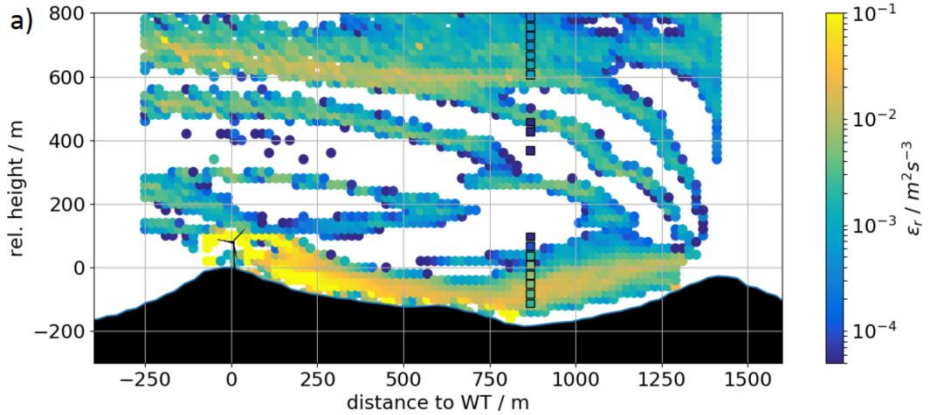
Dual-Doppler lidar



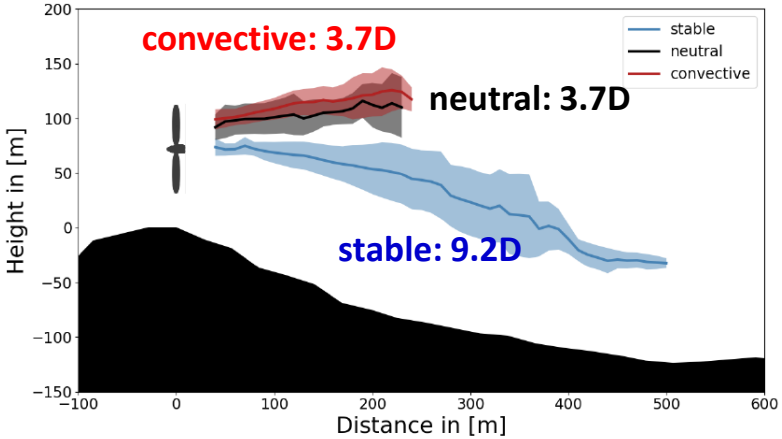
Adaptive scan technique



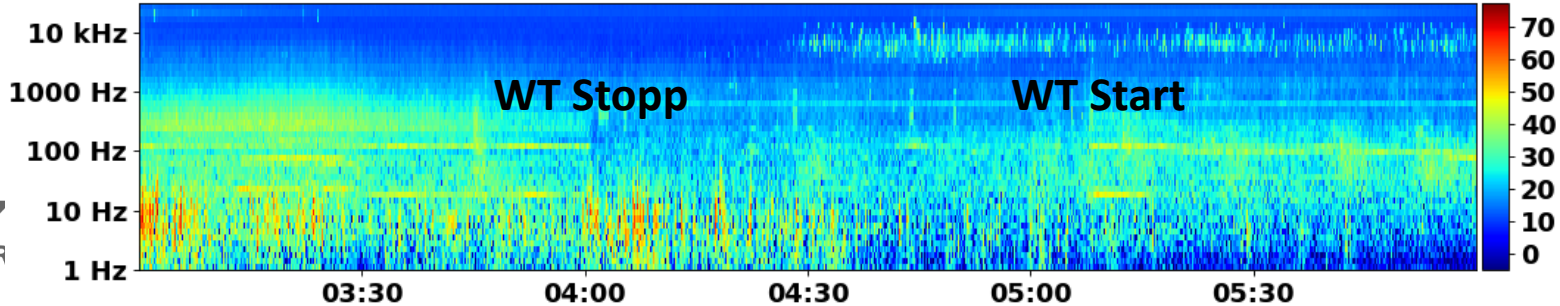
Determination of turbulence with lidar



Wake characterisation

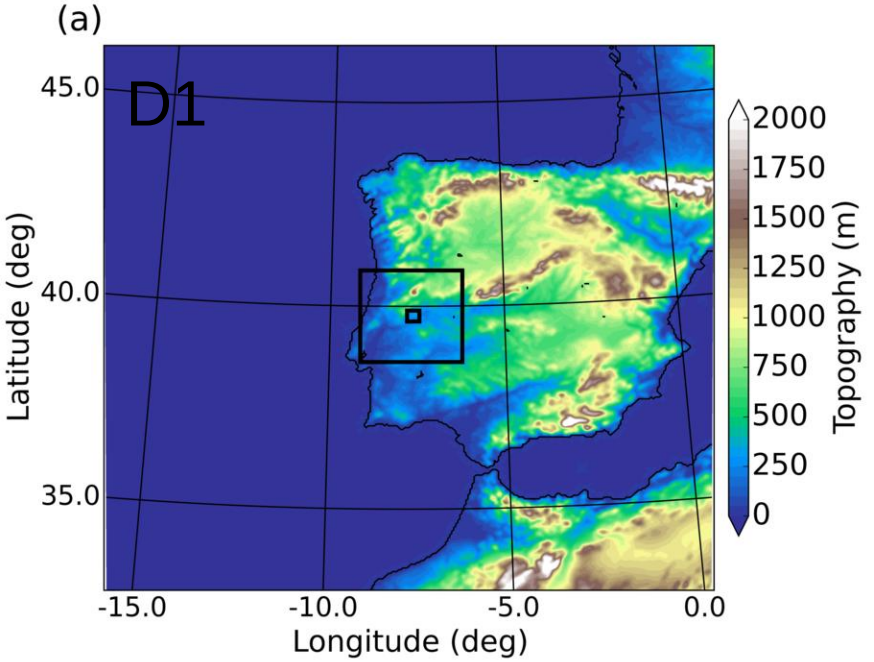


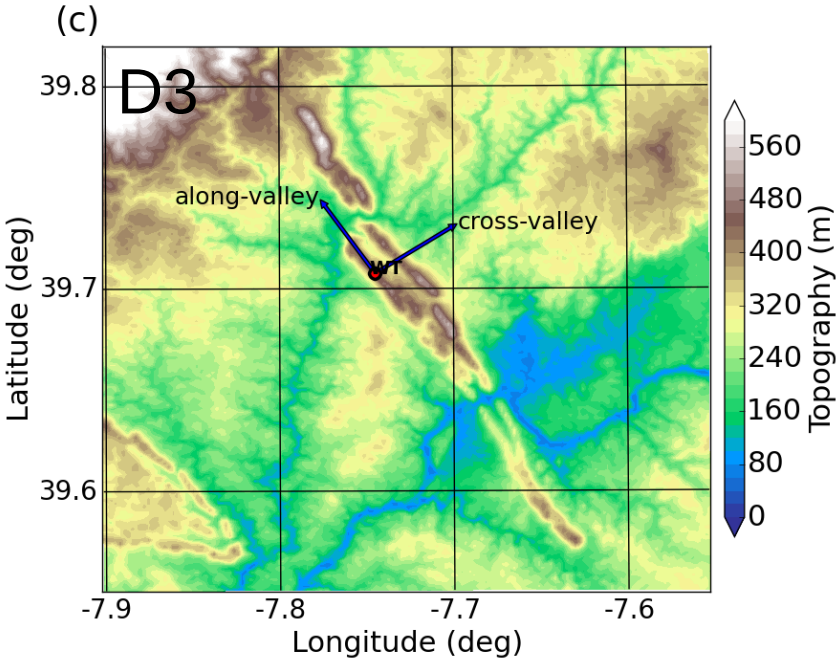
Sound measurements

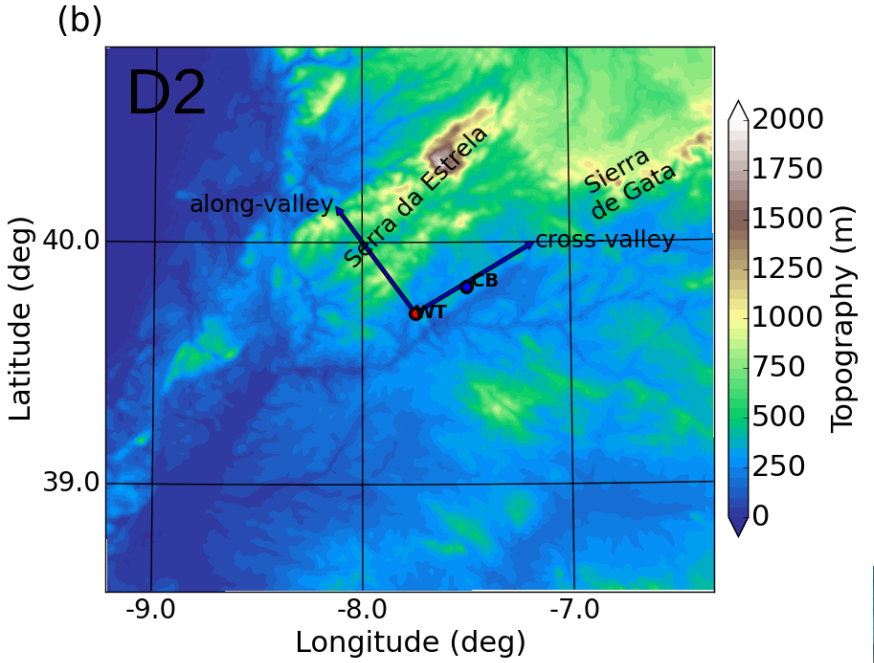


WRF simulations

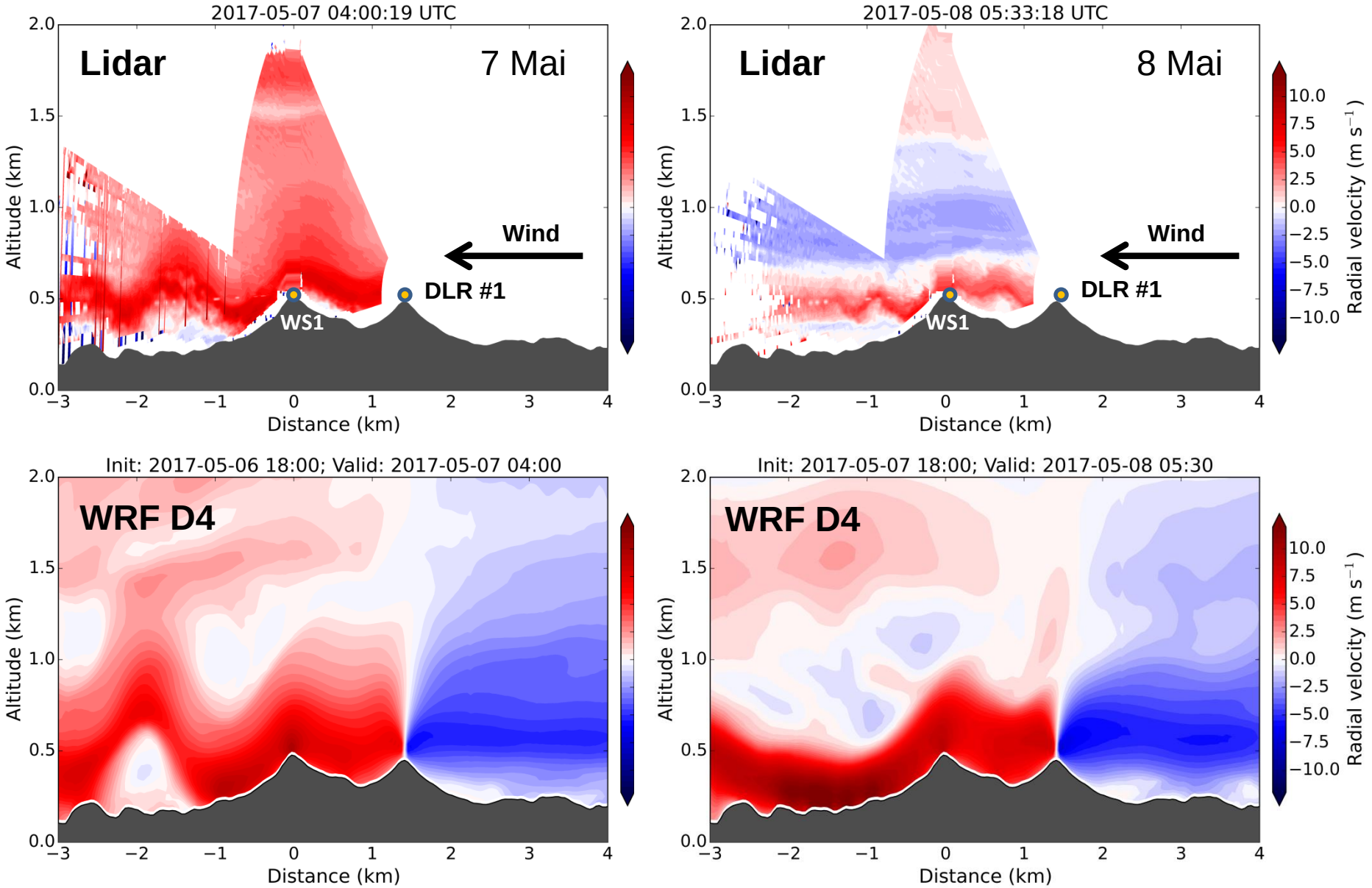
- WRFV 3.8.1 and 4.0.1
- 4 domains: dx=5km, 1km, 200m, 40m
- D3 and D4 in **LES mode + forest parameterization**
- IC/BC: ECMWF operational analysis
- **Aster** topography (30m resolution)
- **Corine** landuse data set
- Long run: 49 days
- Short runs: 12h







Radial velocities



Forest parameterization

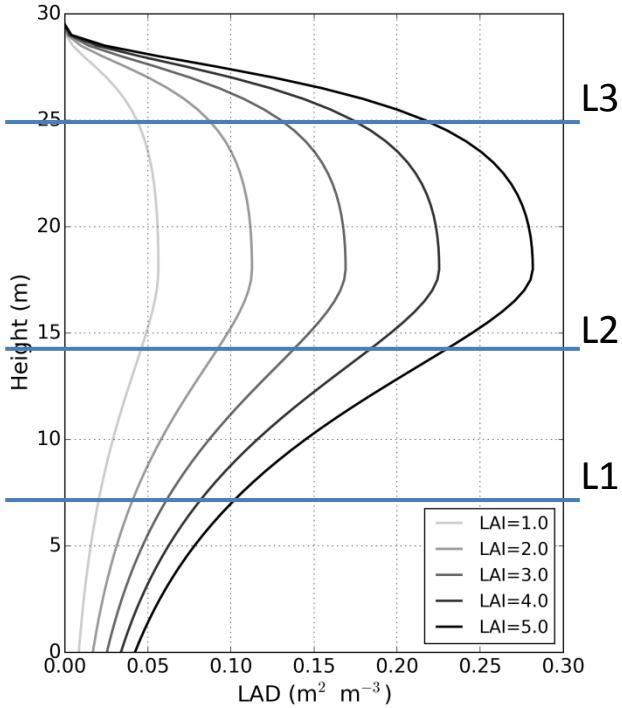
- **Forest drag** (*Shaw and Schumann, 1992*):

$$F_i = -c_d LAD \left|\vec{V}\right| u_i$$

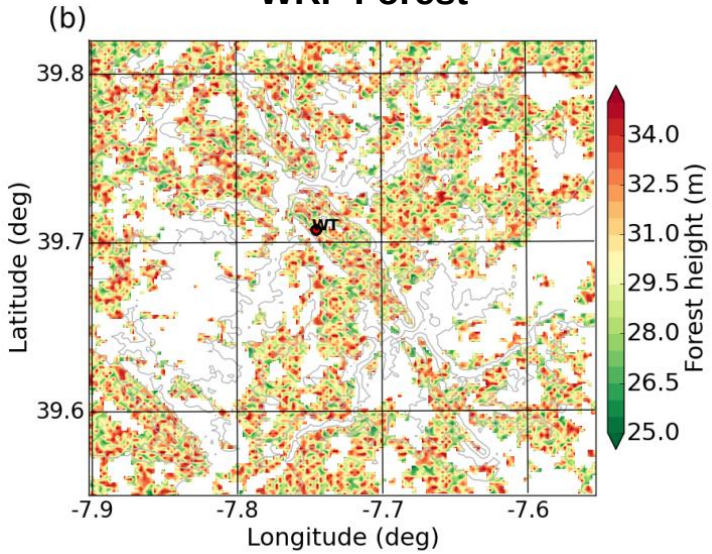
- c_d = 0.15; LAD dependent on $\mathrm{L}AI$ according to *Lalic and Mihailovic, 2004*

- Used tree heights: 30m ± 5m

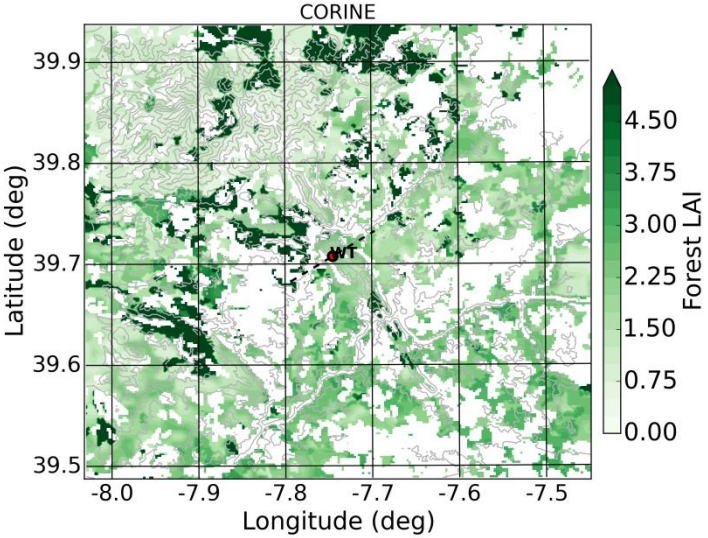
Leaf area density



WRF Forest

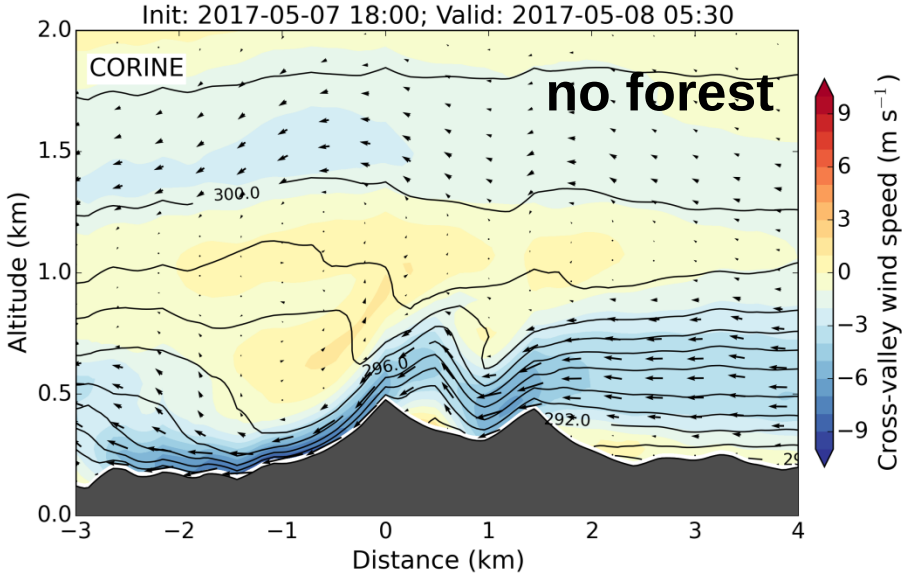


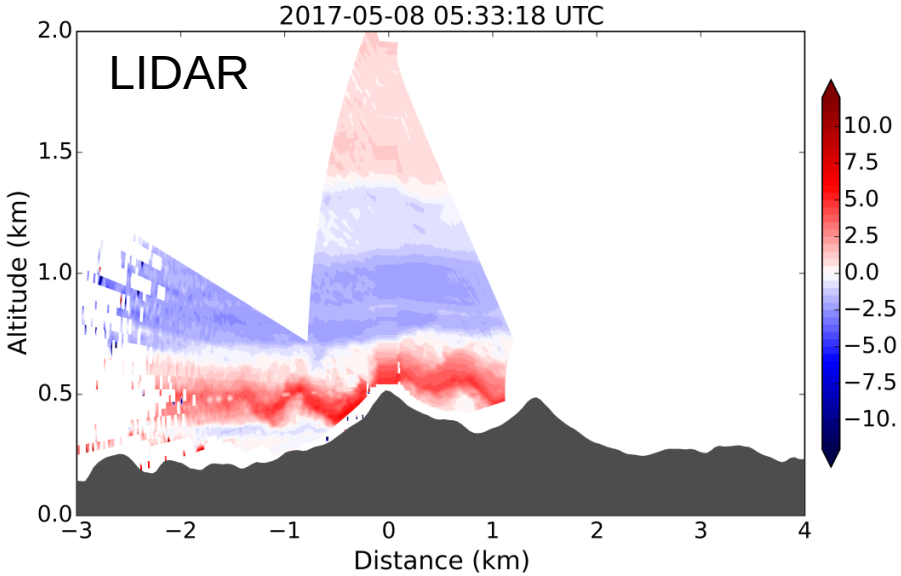
WRF LAI

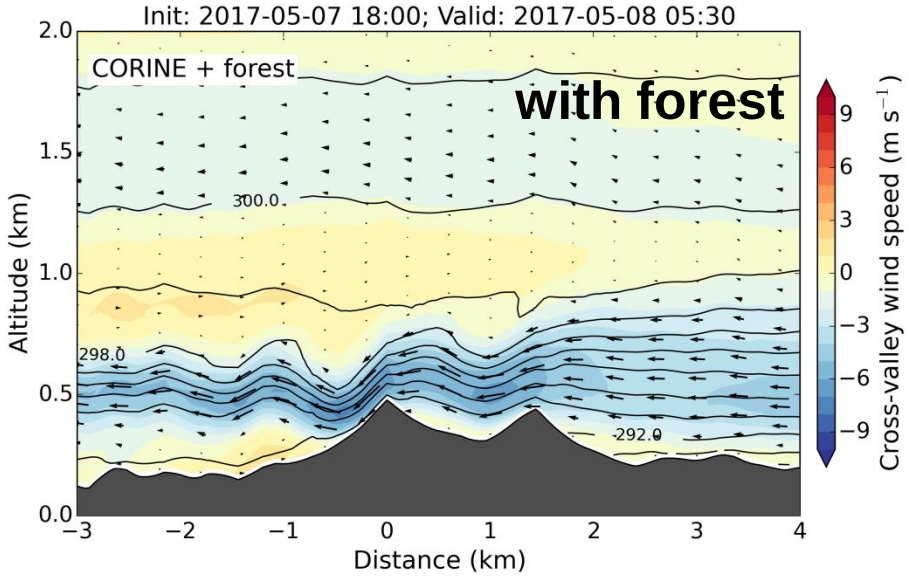


LLJ case (NE)

Improvement by forest drag

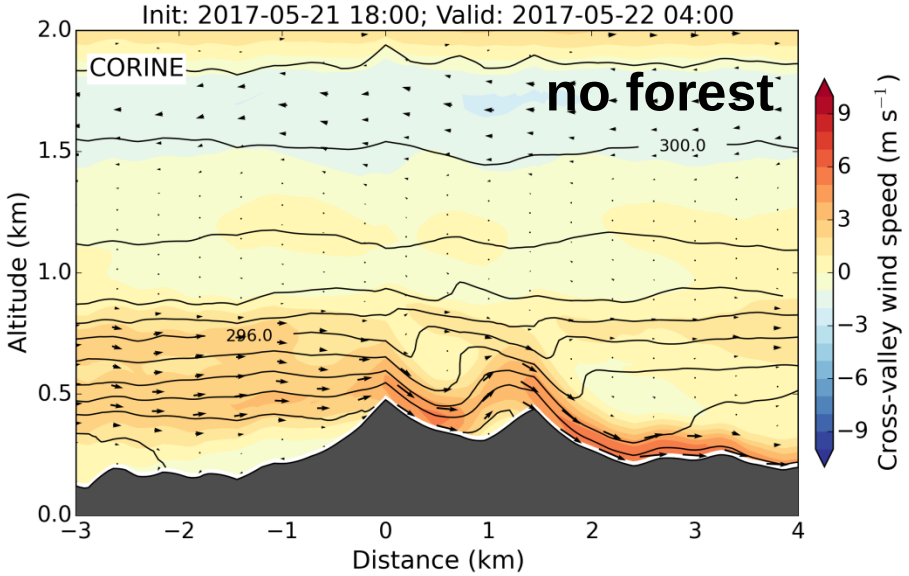


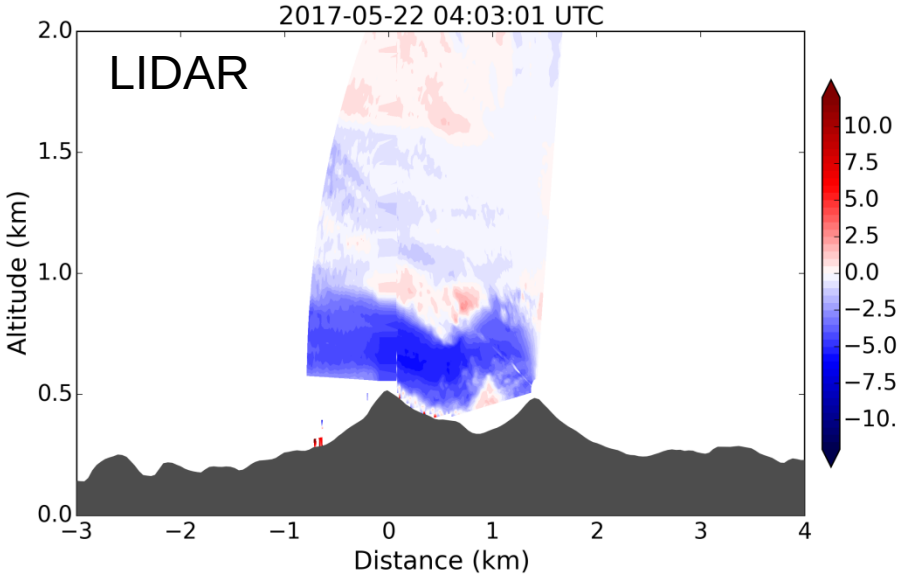


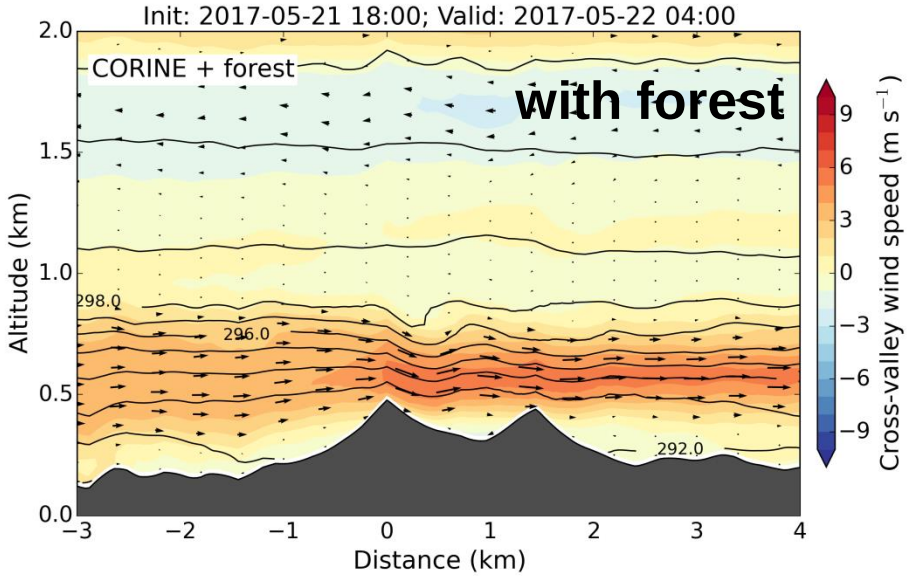


LLJ case (SW)

Improvement by forest drag

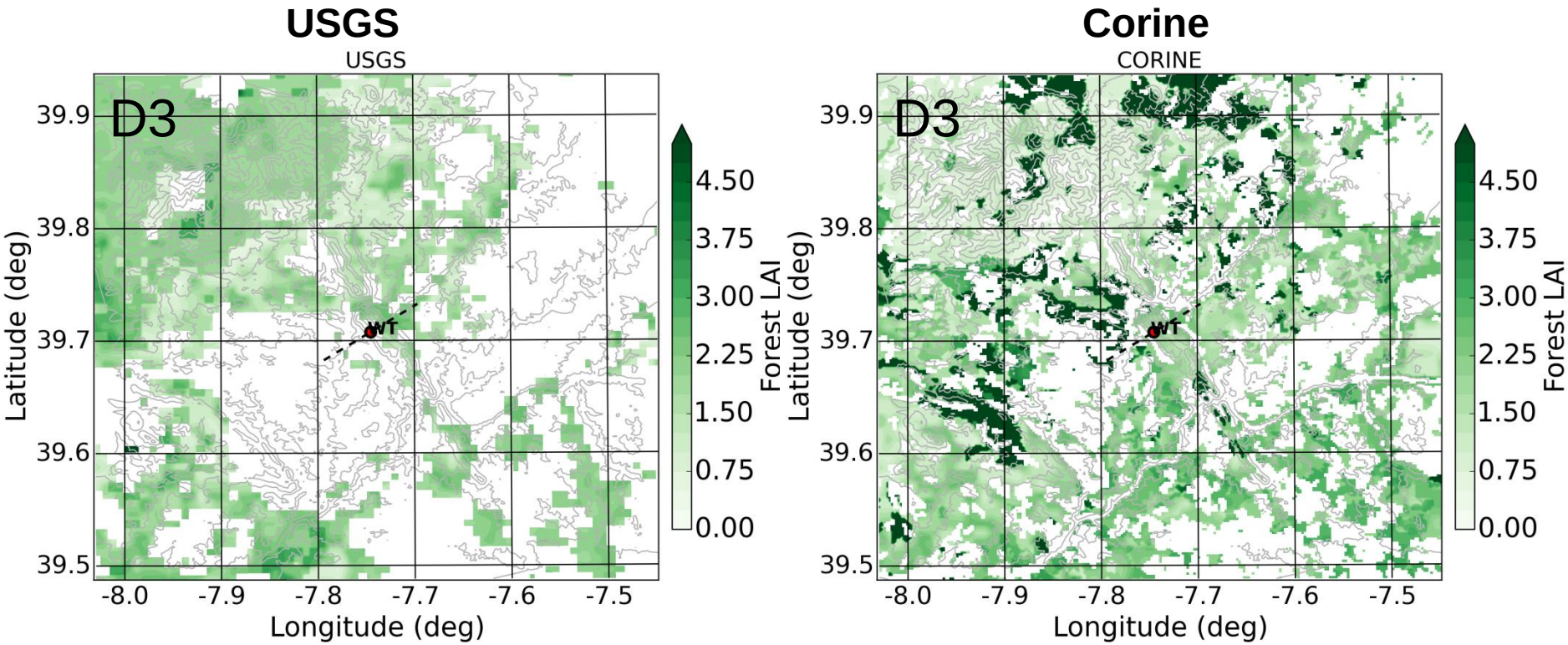




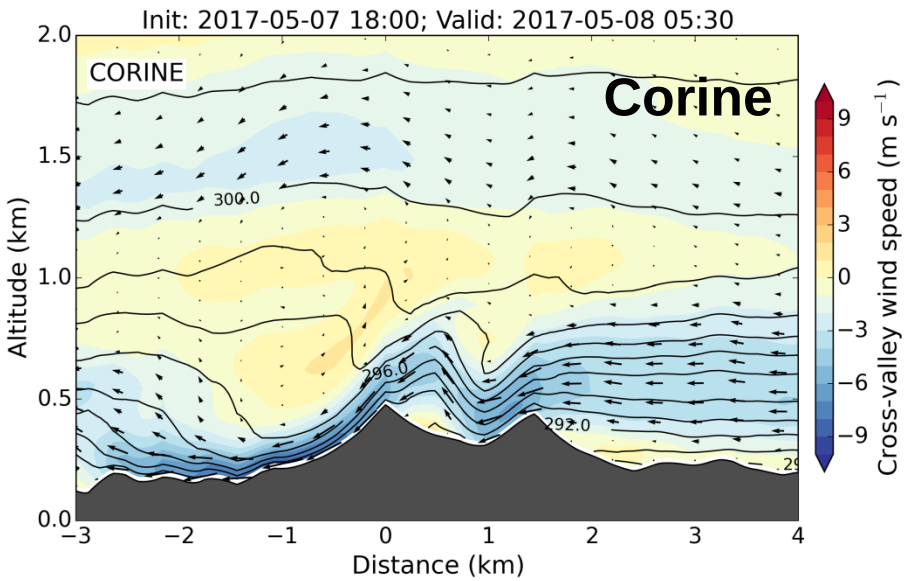


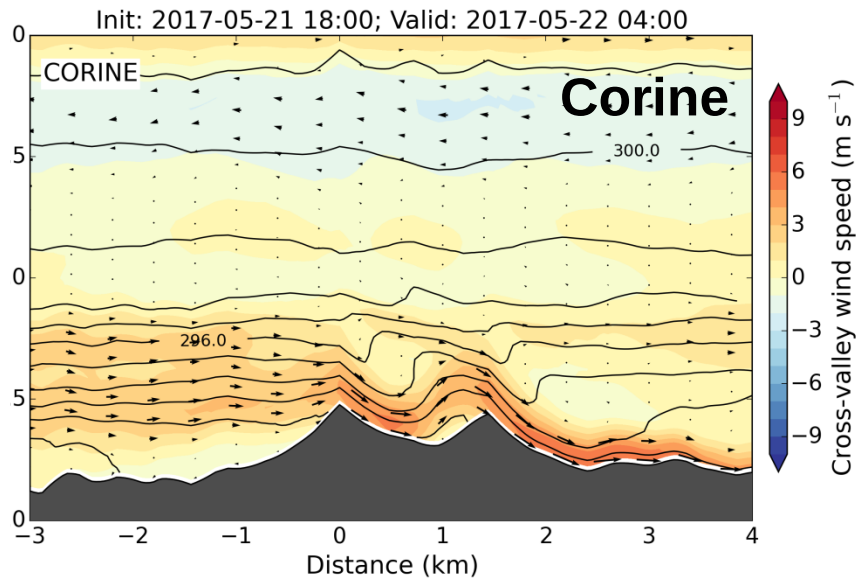
Landuse data

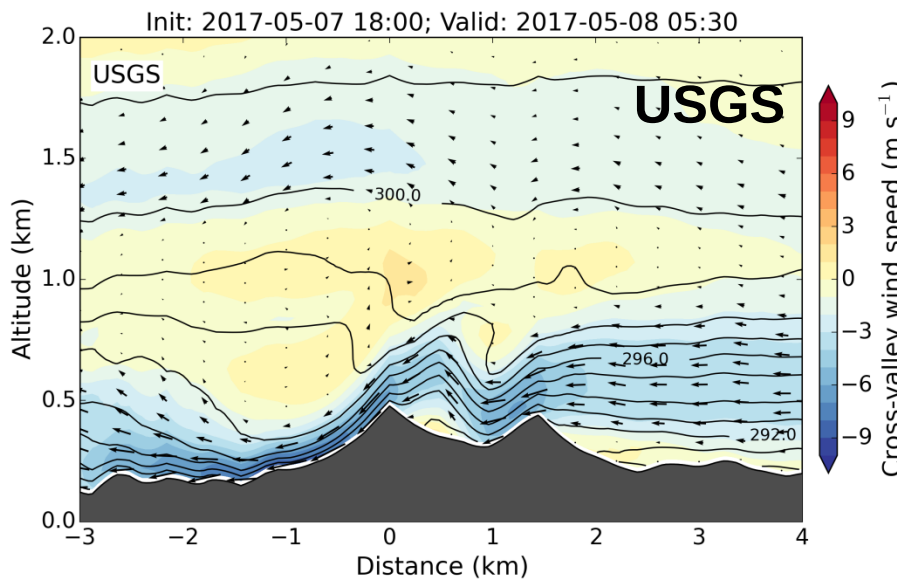
- USGS (1993) and Corine (2012) data sets
- Differences due to resolution and up-to-dateness

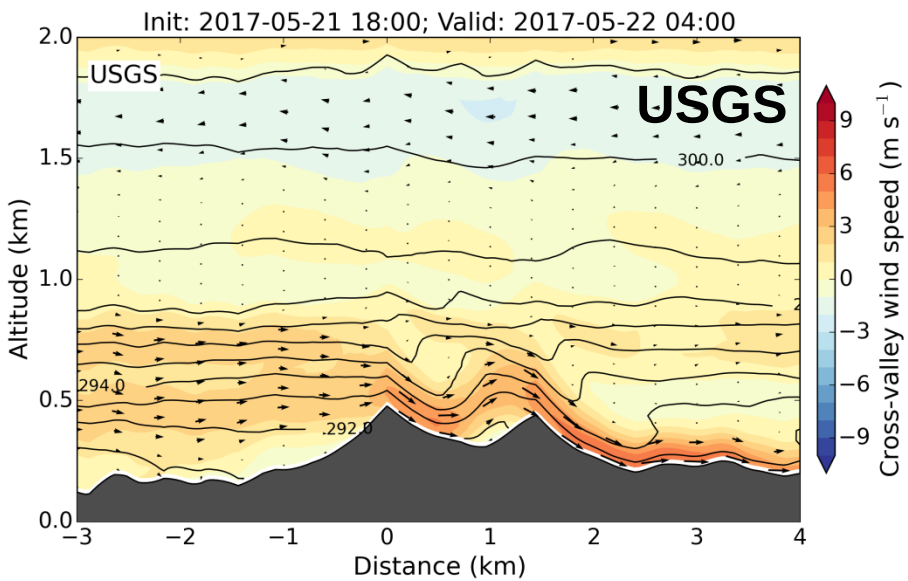


LLJ cases landuse

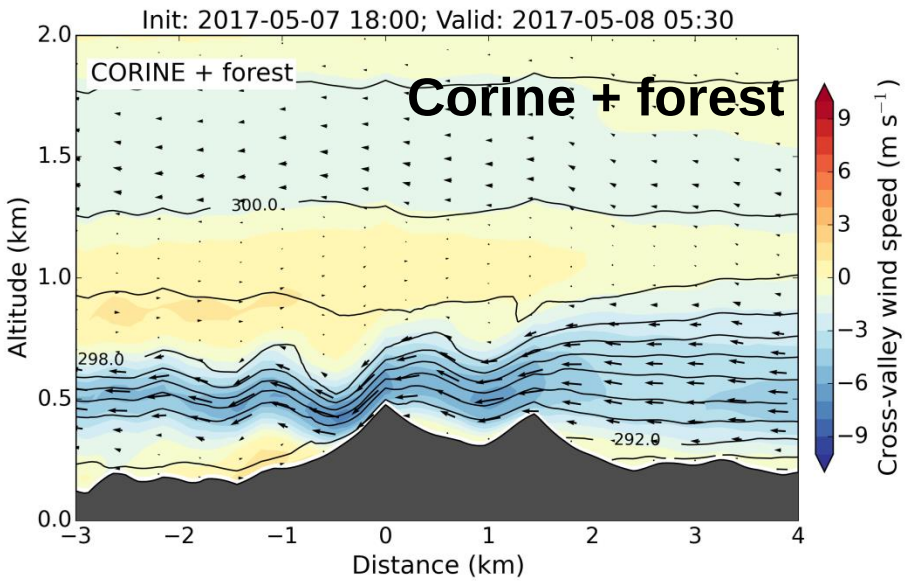


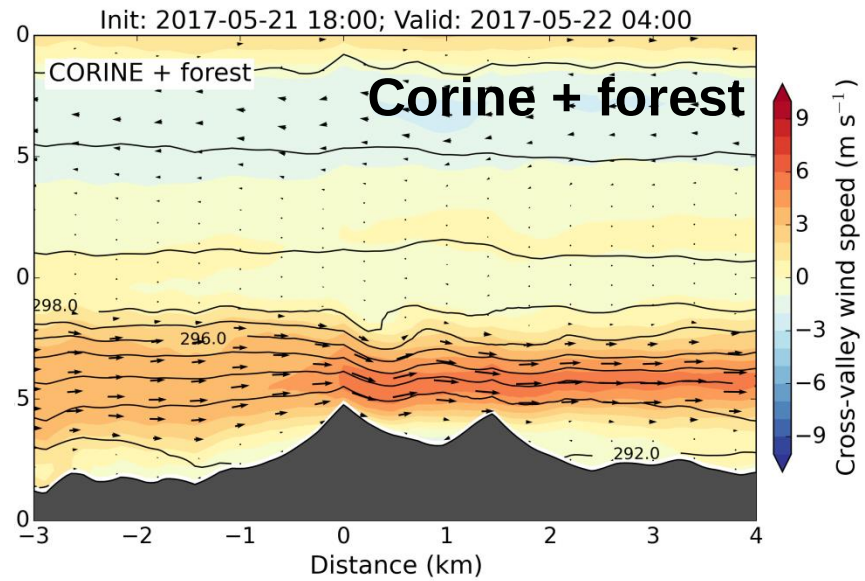


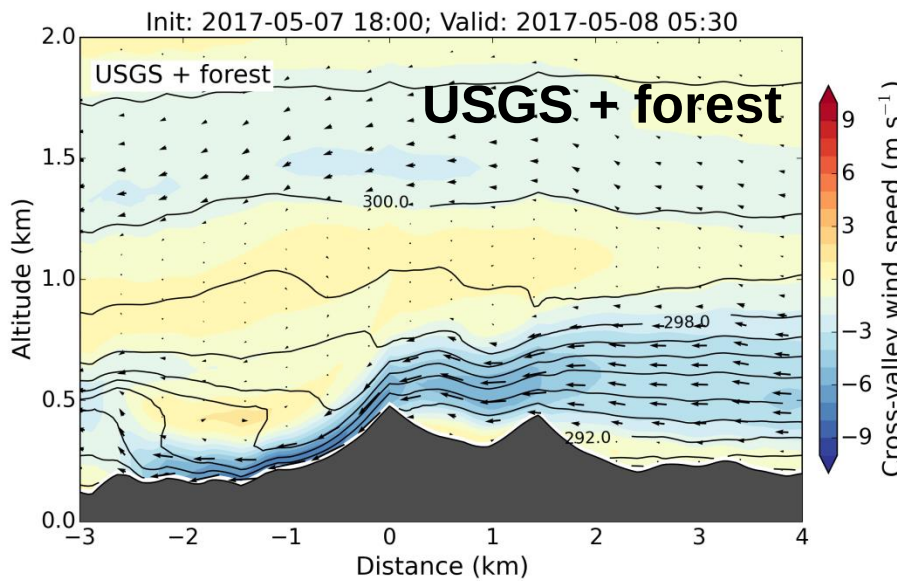


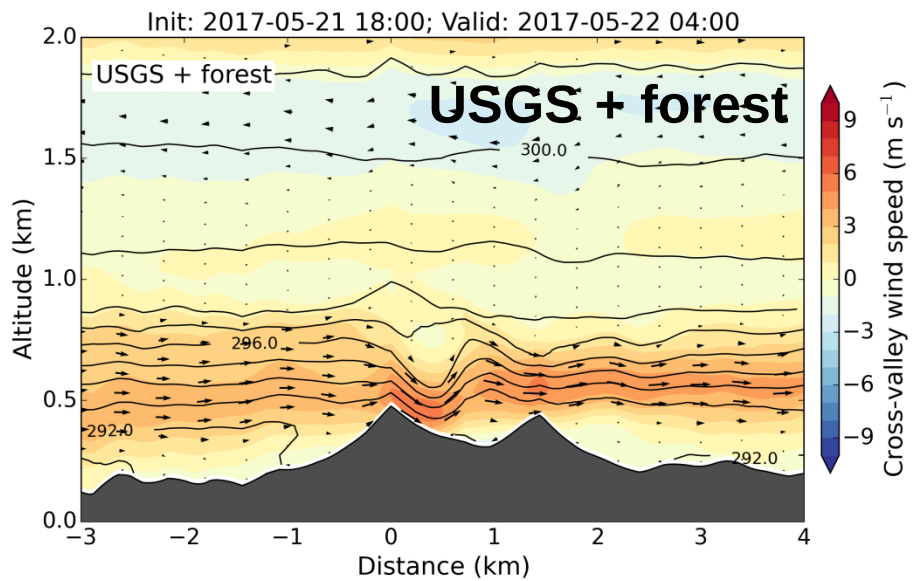


LLJ cases landuse + forest



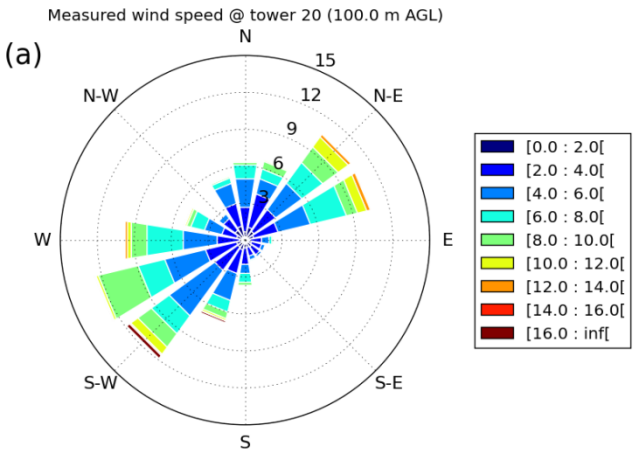




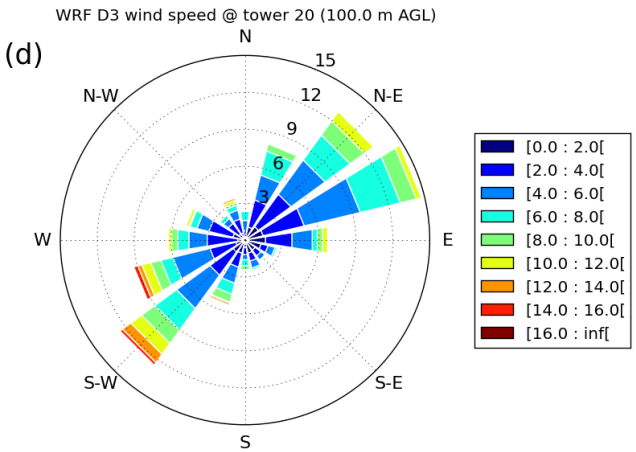


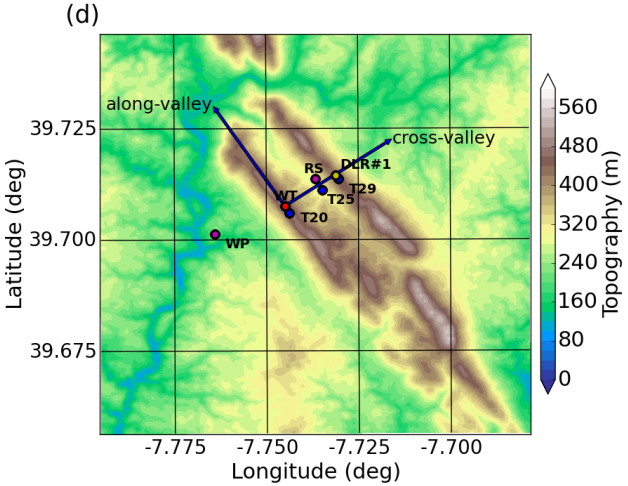
WRF long term simulation D3

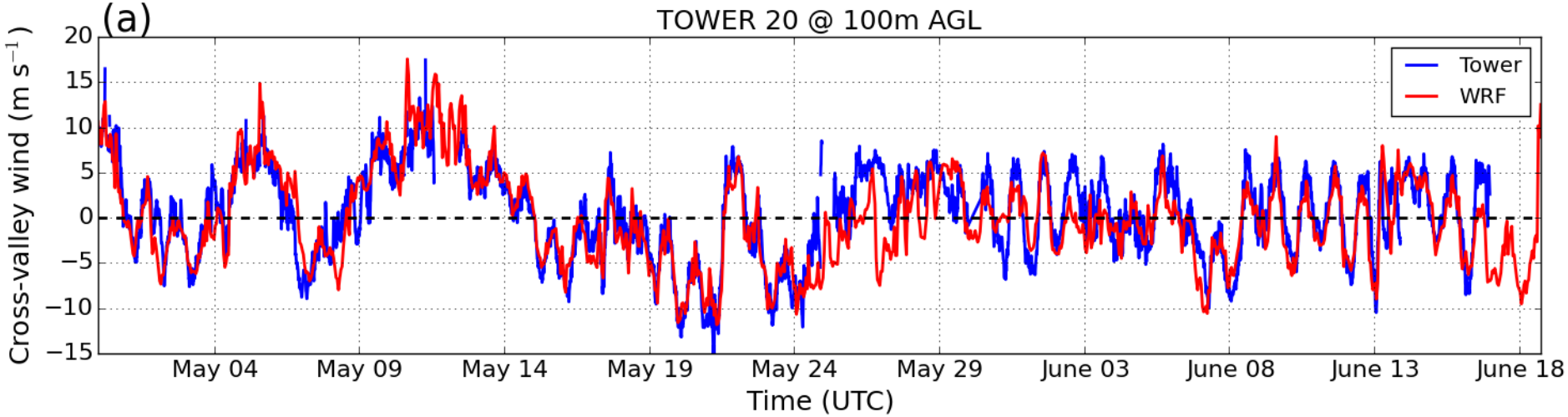
Tower



WRF

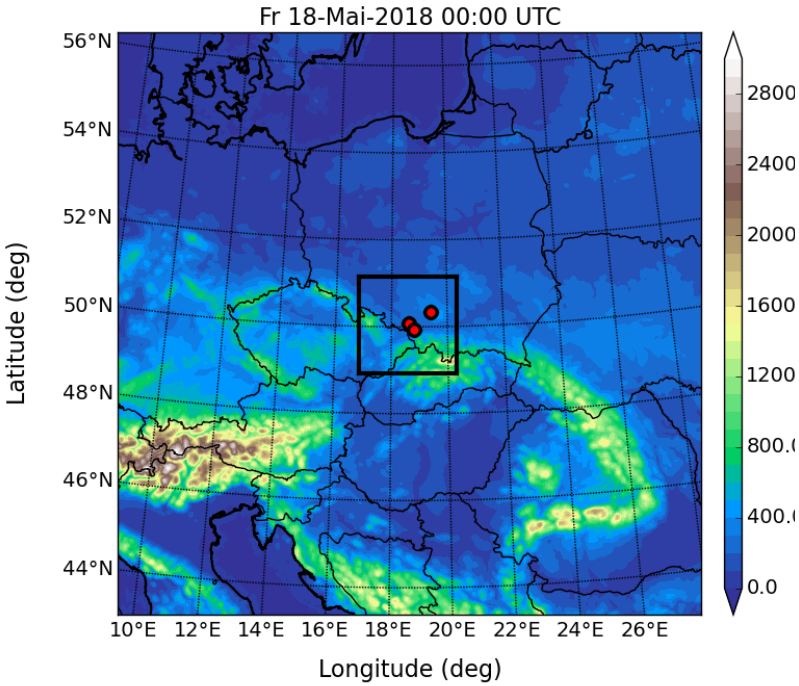




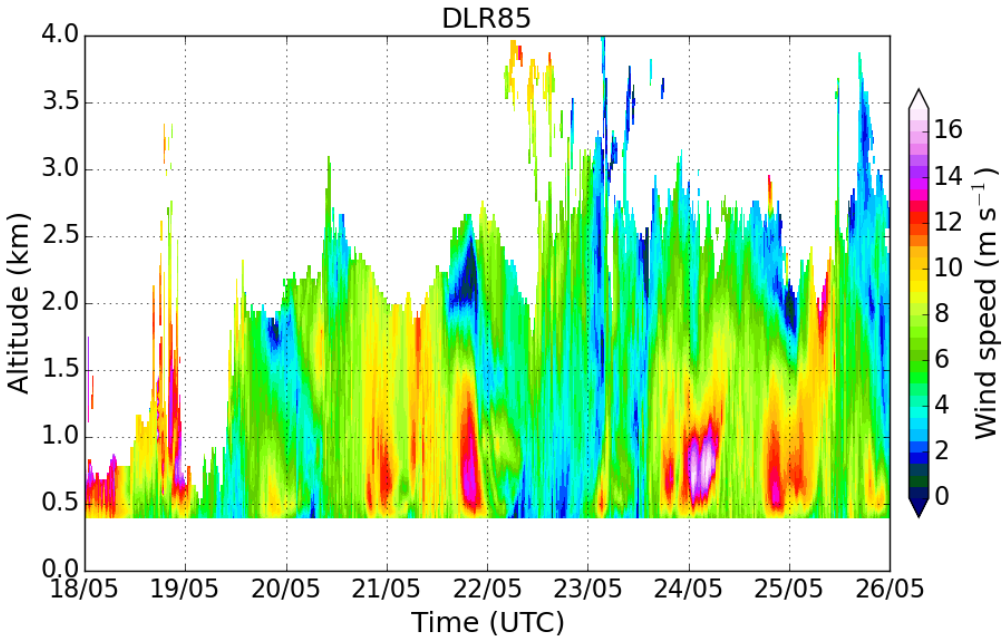


Simulation over less complex terrain: Comet campaign

WRF domains



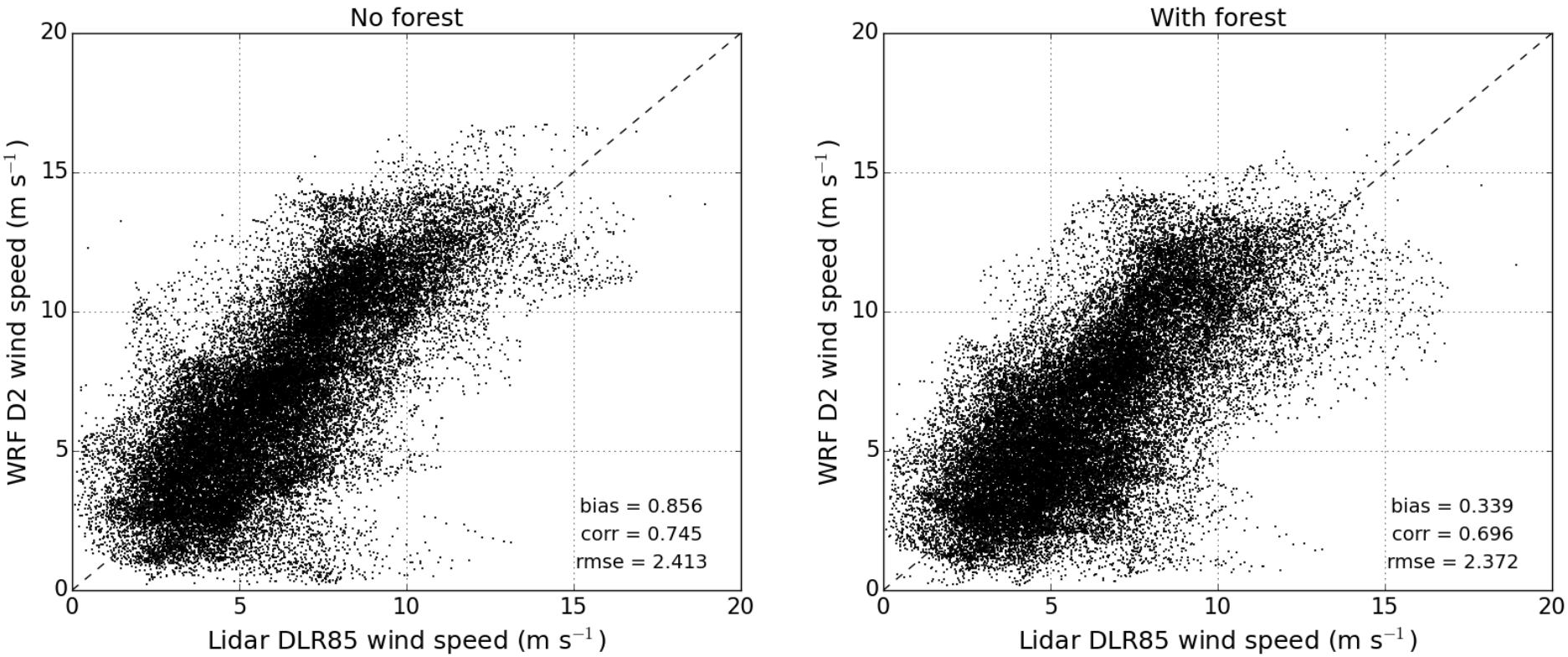
Lidar time series of horiontal wind speed



- Campaign in Silesia 2018 to study CO_2 and CH_4 emissions
- Wind lidar VAD scans over 2 months (May, June 2018)
- WRF simulations with dx=5km and 1km with and without forest
- => comparison with lidars

Simulation over less complex terrain: Comet campaign

Simulation over 8 days



Bias reduced by 0.5 m/s

Conclusions and outlook

- Huge meteorological dataset over complex terrain in Perdigão
- Surface wind speeds **overestimated** by standard WRF
- LLJs considerably improved by **forest parameterization**

- => **Updated landuse data sets** necessary (seasonal variability)
- => Test and quantify impact of forest parameterisation for less complex conditions (Poland, Northern Germany)

Literature

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