



Simulation of the diurnal cycle with the BLLAST dataset and the LES model EULAG

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Main goal:

Investigation of the influence of a **WIND TURBINE** on the
ATMOSPHERIC BOUNDARY LAYER (for complex terrain).





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Current work:

- ↗ Simulation of the diurnal cycle of the BLLAST dataset

⇒ Verification of the LES model towards ABL measurements.



EULAG (EULERian / semi-LAGrangian fluid solver)

- ↗ LES model
- ↗ 3D parallelized
- ↗ Iterative pressure solver MPDATA (robust solver)
- ↗ Different features: steep topography, immersed boundaries, etc.
- ↗ TKE closure
- ↗ Surface fluxes forcing
- ↗ Subsidence forcing
- ↗ Radiative cooling
- ↗ Periodic boundary conditions in the horizontal
- ↗ Variable vertical resolution with $\Delta z=5$ m at the surface; $L_z=3$ km
- ↗ Different horizontal resolutions and domain sizes, dependent on the time of the day



Diurnal cycle method

night	e s i r n u s	day	t e s n u s	night
SBL		CBL		SBL
$n=m=128$		$n=m=128$		$n=m=512$
$\Delta x = \Delta y = 6.25 \text{ m}$		$\Delta x = \Delta y = 25 \text{ m}$		$\Delta x = \Delta y = 6.25 \text{ m}$
$L_x = L_y = 800 \text{ m}$		$L_x = L_y = 3200 \text{ m}$		$L_x = L_y = 3200 \text{ m}$
$\text{procs} = 8 \times 8 \times 4 = 256$		$\text{procs} = 8 \times 8 \times 4 = 256$		$\text{procs} = 16 \times 16 \times 4 = 1024$



Case study conditions

- ↗ **Anticyclonic conditions**

- lower troposphere governed by mountain-plain circulation

- CBL: clear or with a few cumulus clouds (no deep clouds!) → dry simulations)

- ↗ **Homogenous surface**

- ↗ **Surface fluxes**

- forcing

- ↗ **Vertical profiles**

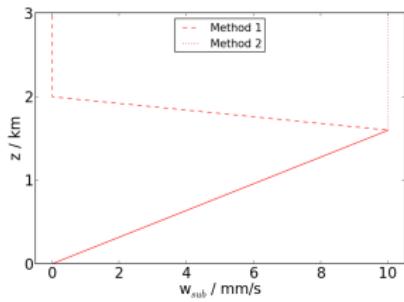
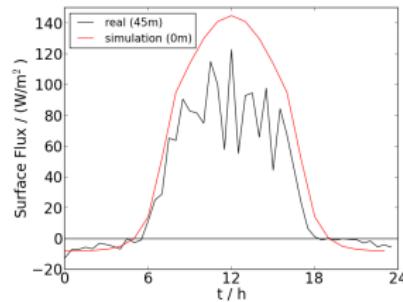
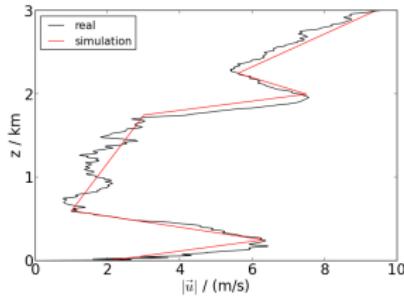
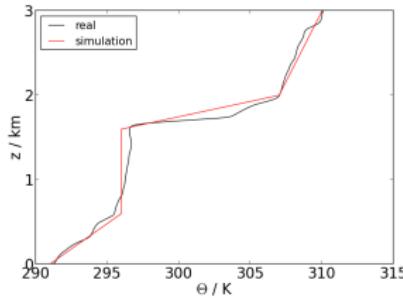
- initial conditions, subsidence (forcing), comparison

⇒ **01.07.2011 (IOP)**

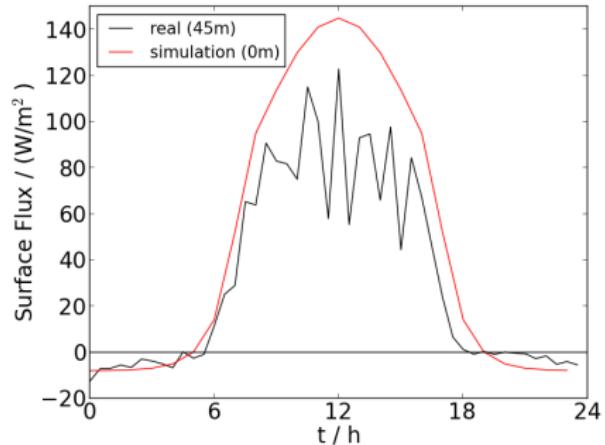
⇒ **60-m tower → surface fluxes**

⇒ **MODEM-radiosoundings → vertical profiles**

BLLAST Simulation: set-up

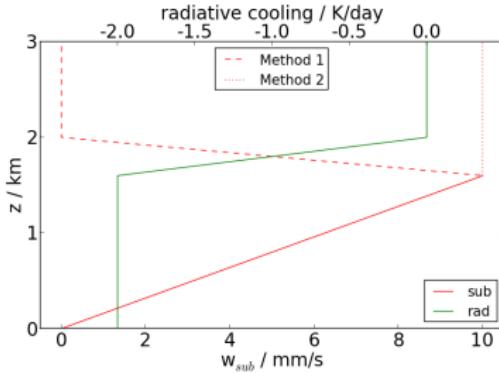


Surface Flux Forcing



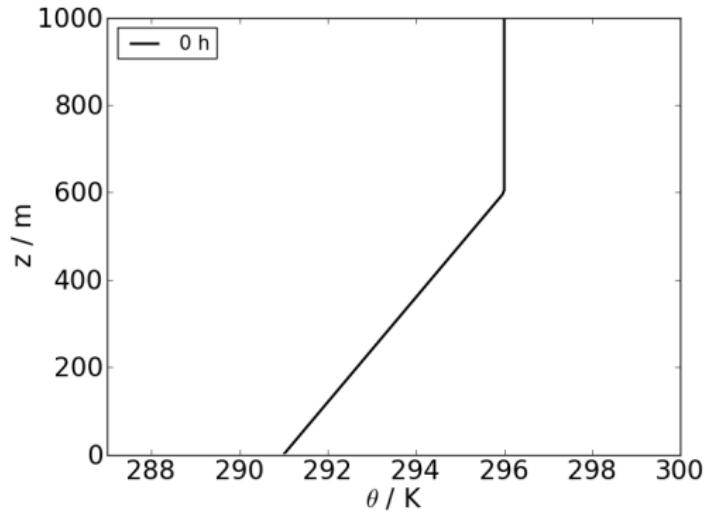
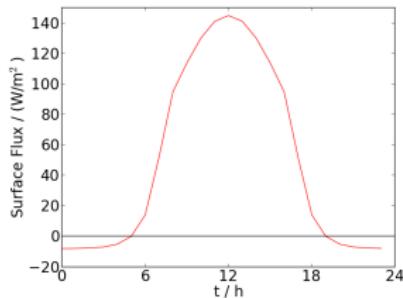
- ↗ real (45 m): average of the fluxes at 30 m, 45 m and 60 m from 60-m tower
- ↗ simulation (0 m): exponential flux distribution with height (300 m = e-folding scale)
- ↗ SHF profile: symmetric around 1200 UTC
- ↗ SBL → CBL: 4 h → 6 h; CBL → SBL: 18 h → 20 h

Subsidence Forcing

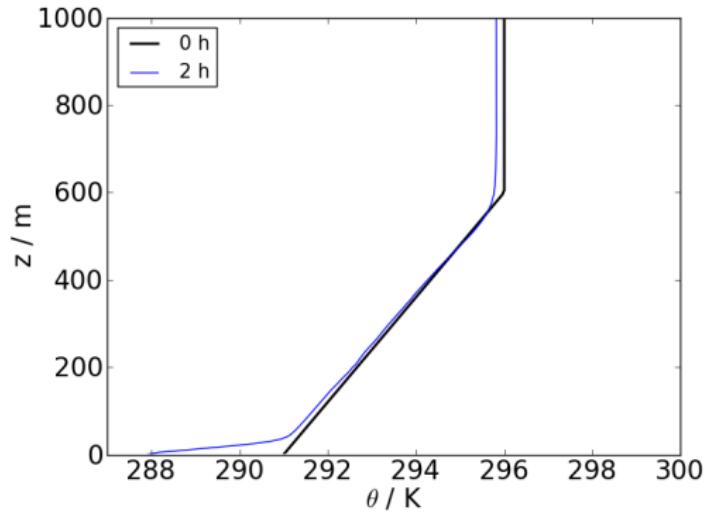
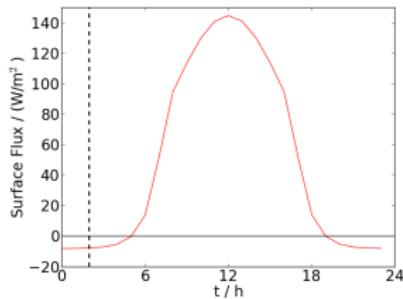


- ↗ Vertical profiles at 0000 UTC, 1100 UTC, 1658 UTC and 2254 UTC
→ $w_{sub}(0000 \text{ UTC} - 1100 \text{ UTC}) \sim 10 \text{ mm s}^{-1}$
- ↗ Linear increase of w_{sub} from the ground up to the residual layer
- ↗ Method 1: Linear decrease of w_{sub} up to the top of the inversion layer; $w_{sub}=0$ in FA
- ↗ Method 2: Inversion layer and FA: constant w_{sub}
- ↗ Subsidence applied on u, v and Θ or only on Θ (moisture=0)
- ↗ Subsidence horizontally applied on each gp $\Theta(i,j)$ or as large-scale process on $\overline{\Theta(i,j)}$
- ↗ Radiative cooling of 2 K d^{-1} as additional forcing

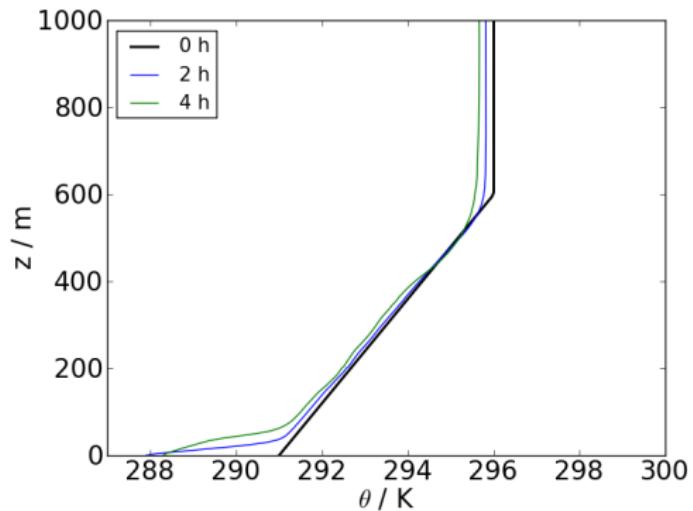
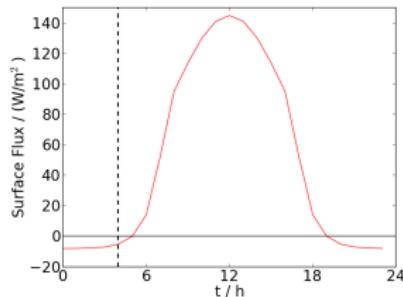
First results: Temperature development



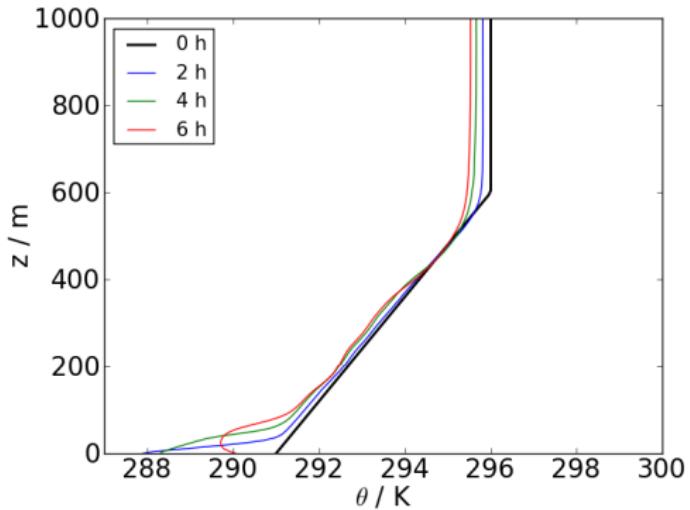
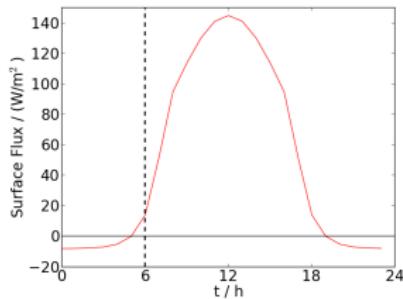
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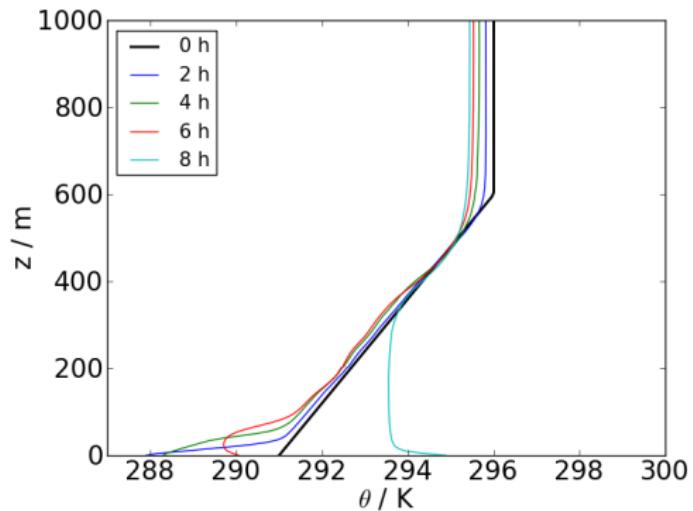
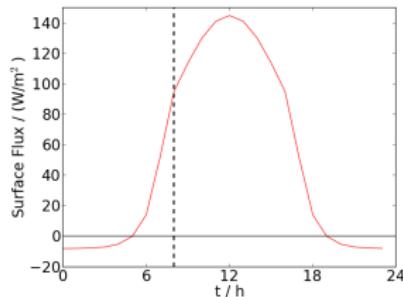
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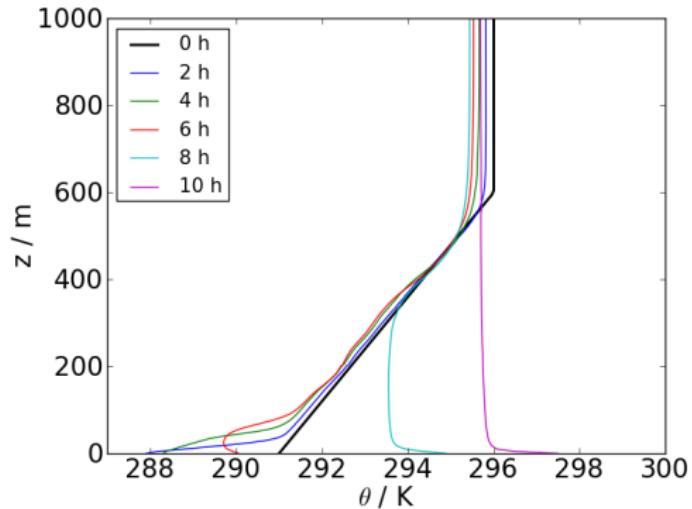
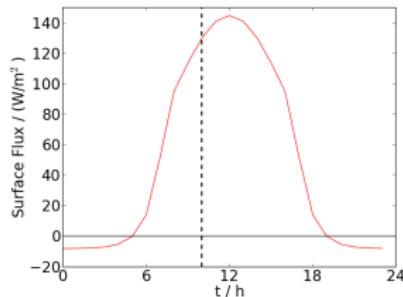
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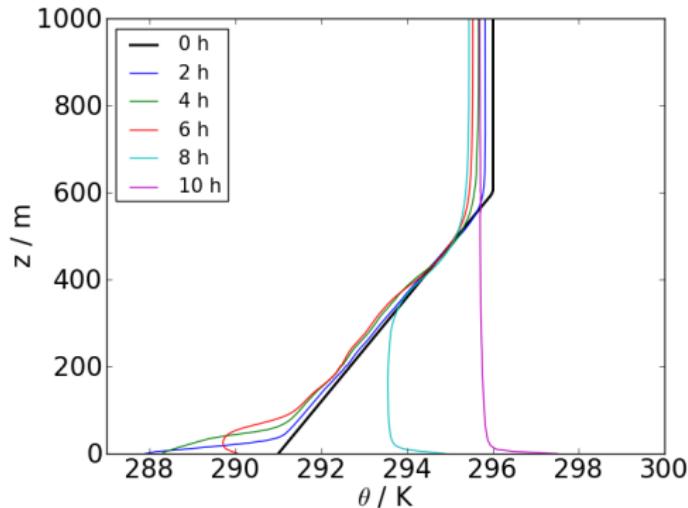
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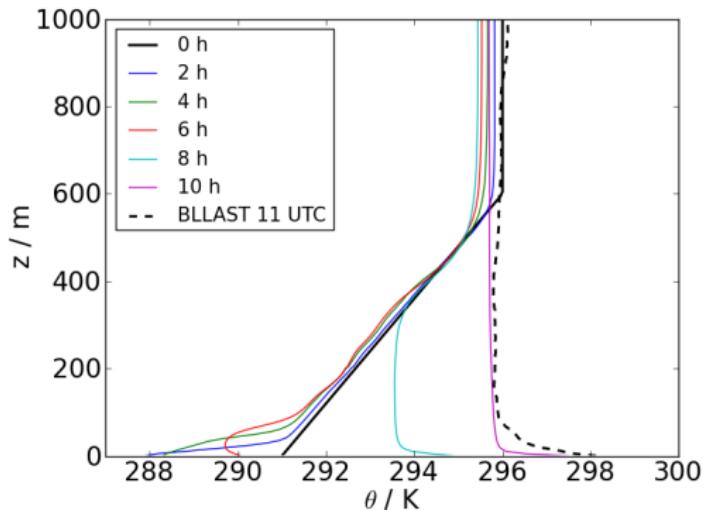


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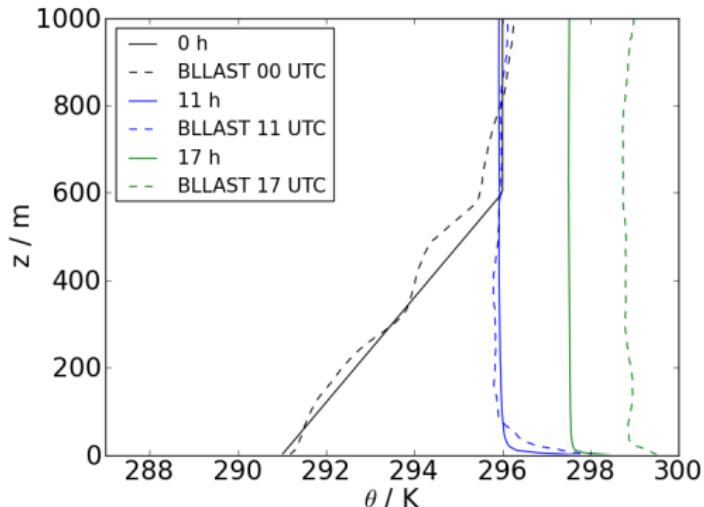
→ Transition from SBL to CBL.

First results: Comparison to measurements



→ Comparison of the vertical Θ -structure leads to a quite good result.

First results: Comparison to measurements



- ⇒ Quite good agreement for 1100 UTC.
- ⇒ $\Delta\Theta$ is 1 K for 1658 UTC.



Summary

Preleminary results:

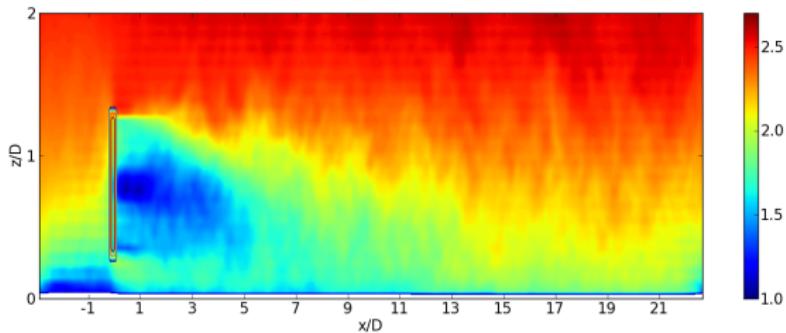
- ↗ Transition from SBL to CBL
- ↗ Agreement of Θ -profile for 1100 UTC
- ↗ Underestimation of Θ -profile for 1658 UTC (dry simulations)

Work in progress:

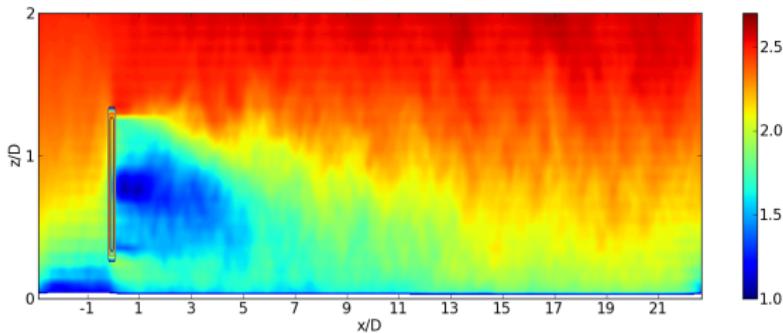
- ↗ e-folding scale for exponential surface flux distribution; drag parameter
- ↗ Subsidence process
- ↗ Transition from CBL back to SBL
- ↗ Θ -profile comparison for 2254 UTC
- ↗ Investigation of the spectra and the TKE parts



Outlook

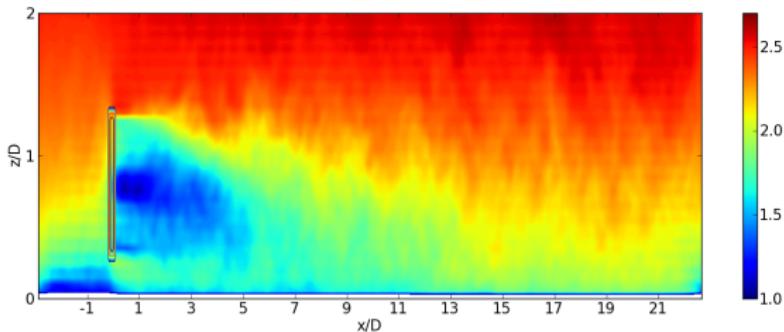


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Thank you for your attention!