

# High-resolution simulation of the evening transition in the atmospheric boundary layer with the spectral element method



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Bolin Centre  
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**SERC**  
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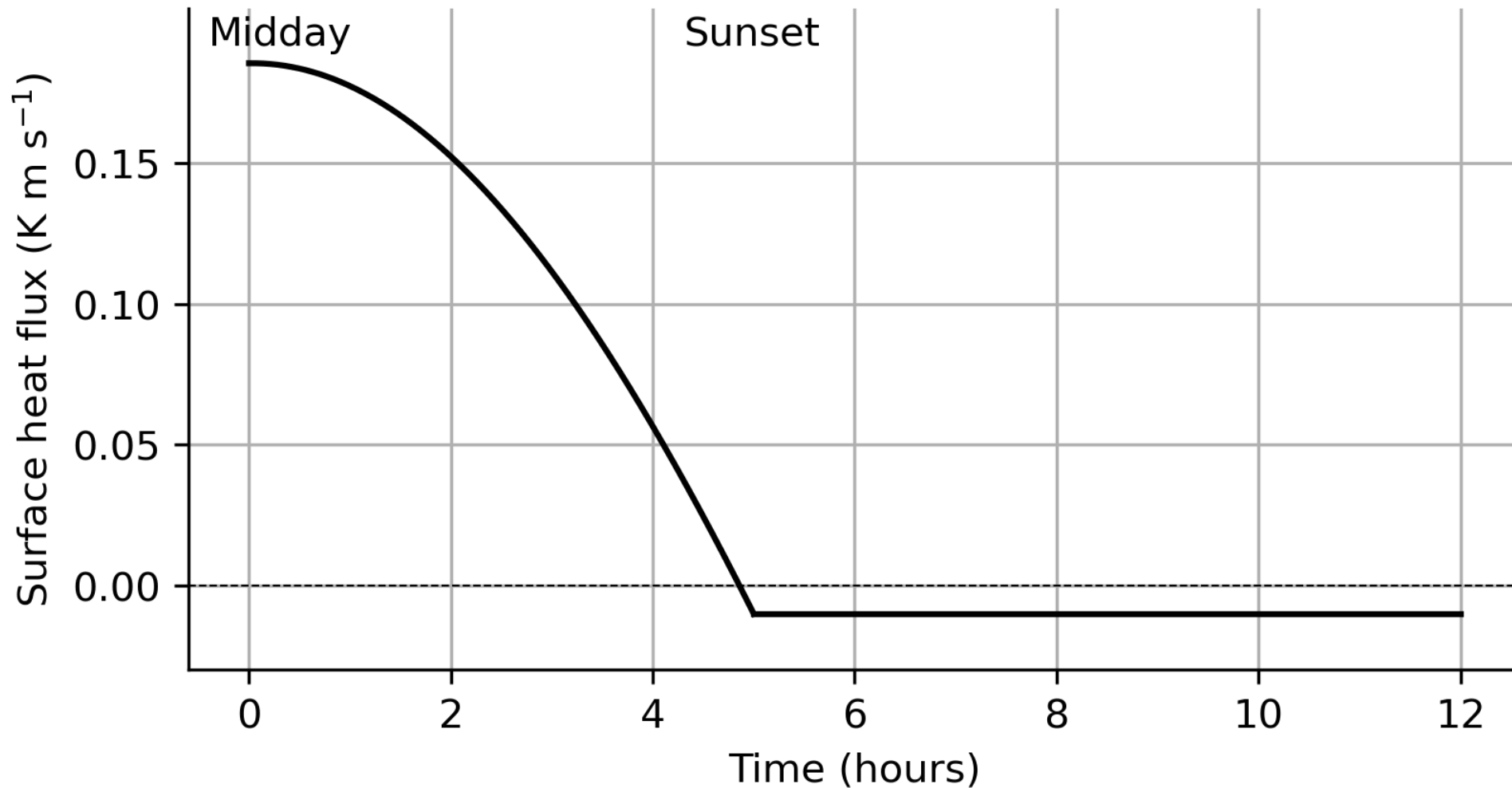
KAUST | Timofey Mukha

NCAR | Peter Sullivan

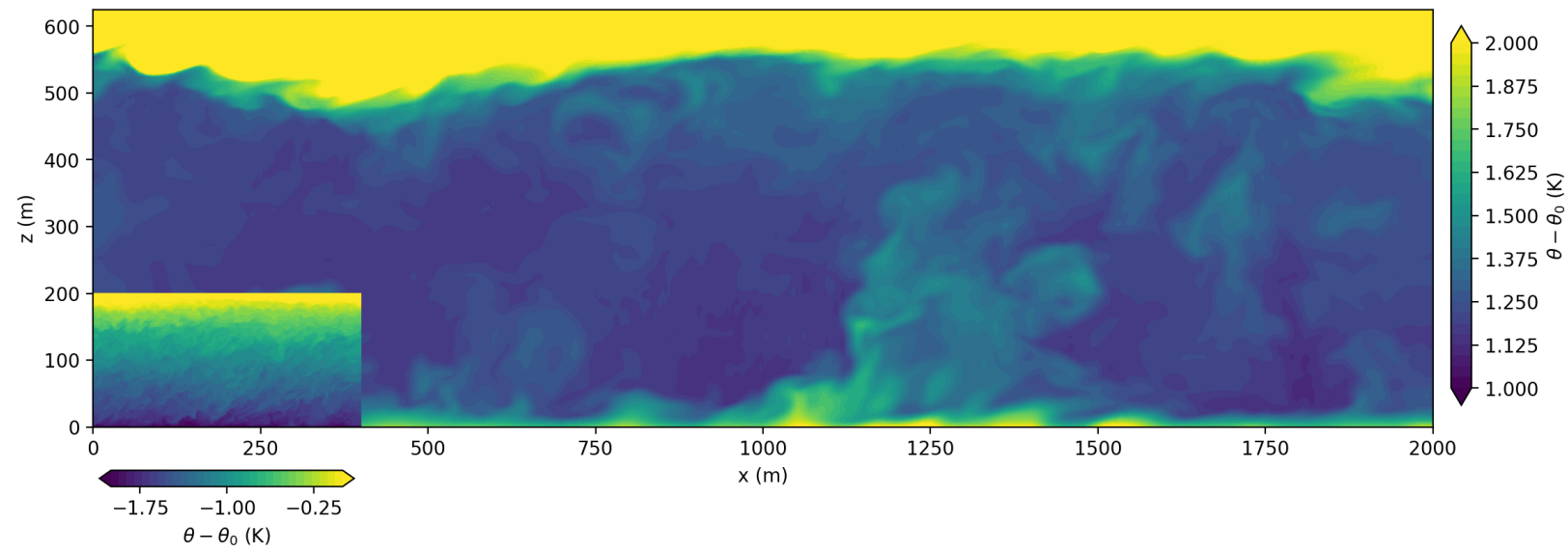
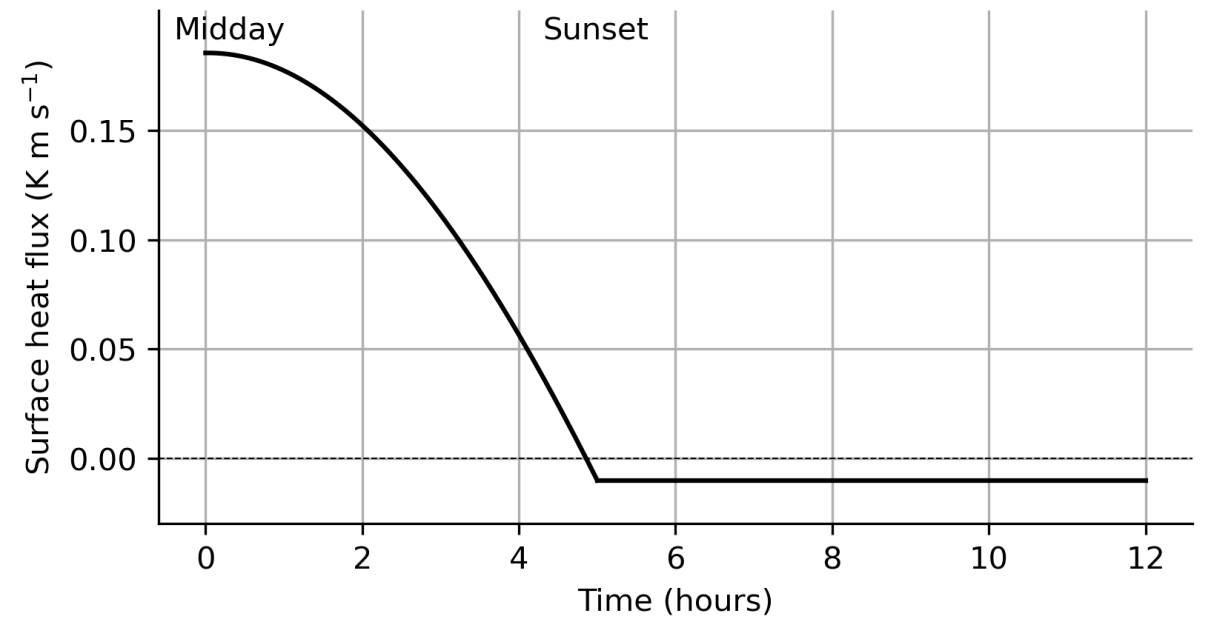
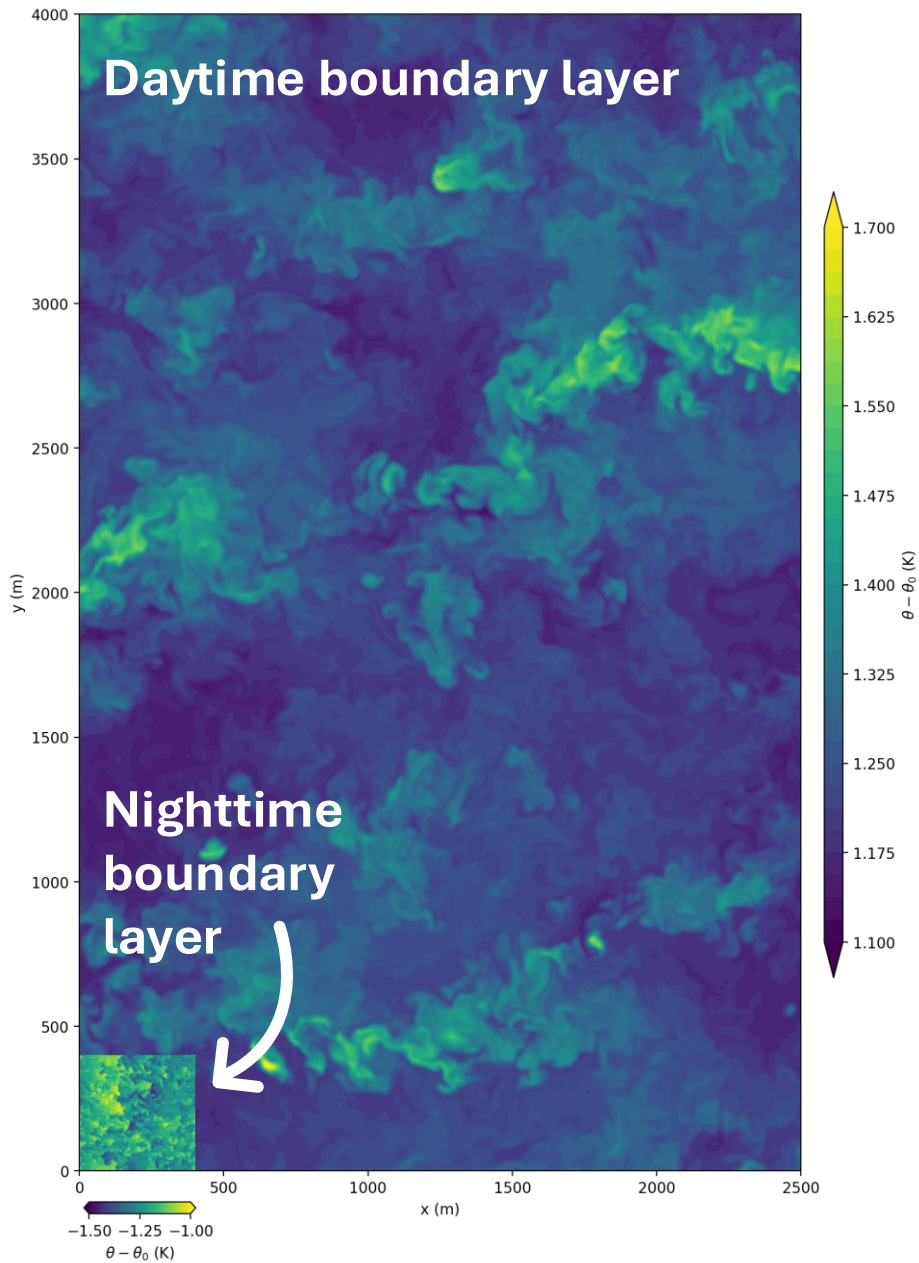
FAU | Philipp Schlatter

Stockholm University | Gunilla Svensson

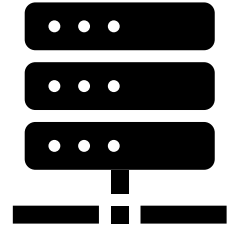
# We want to simulate the evening transition with LES...



... but the scales of the daytime and nighttime boundary layers are tremendously different



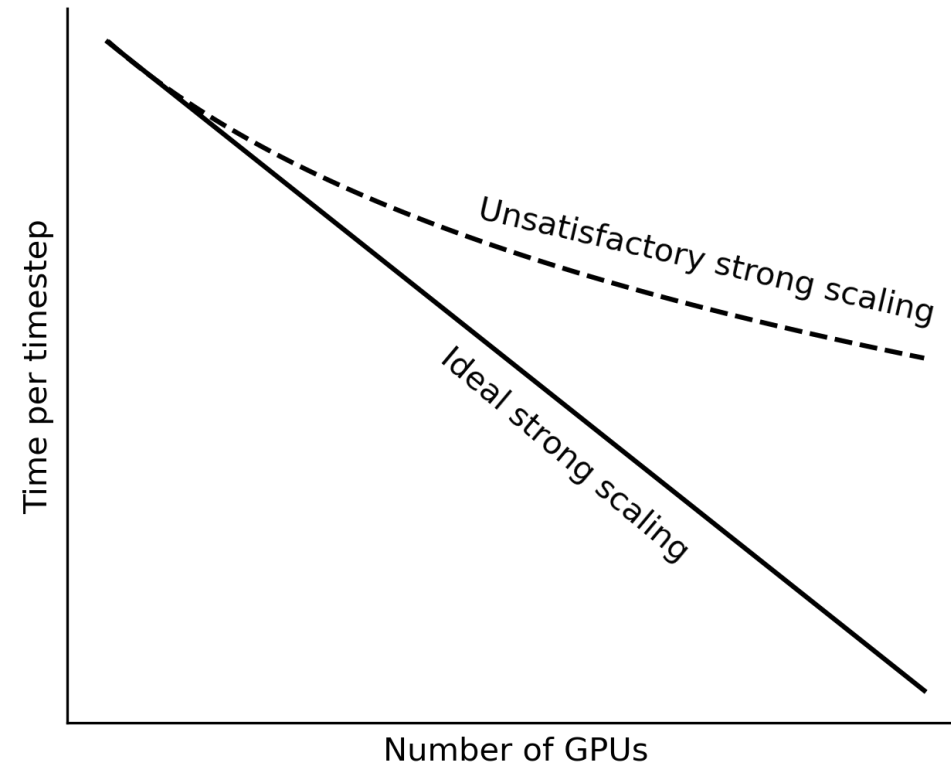
The computational power needed for high-resolution LES of the evening transition exists today



*But to **utilise it effectively** we need a good solver*

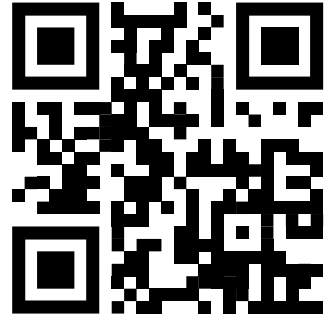
We need a solver that...

- Runs on different types of hardware
- Scales well on large compute clusters





[neko.cfd](http://neko.cfd)



## Introducing **Neko**: a spectral element solver

- Highly parallelizable
- Runs on CPU and GPU
- Flexible: runs on Nvidia and AMD GPUs, and can easily be adapted for other backends
- Open source
- Active user community

# Neko scales almost perfectly to 80% of LUMI

**Test case:**

**Rayleigh–Bénard convection in a cylinder**

Aspect ratio 1:10,  $Ra = 10^{15}$

108M elements, 7<sup>th</sup> order polynomials

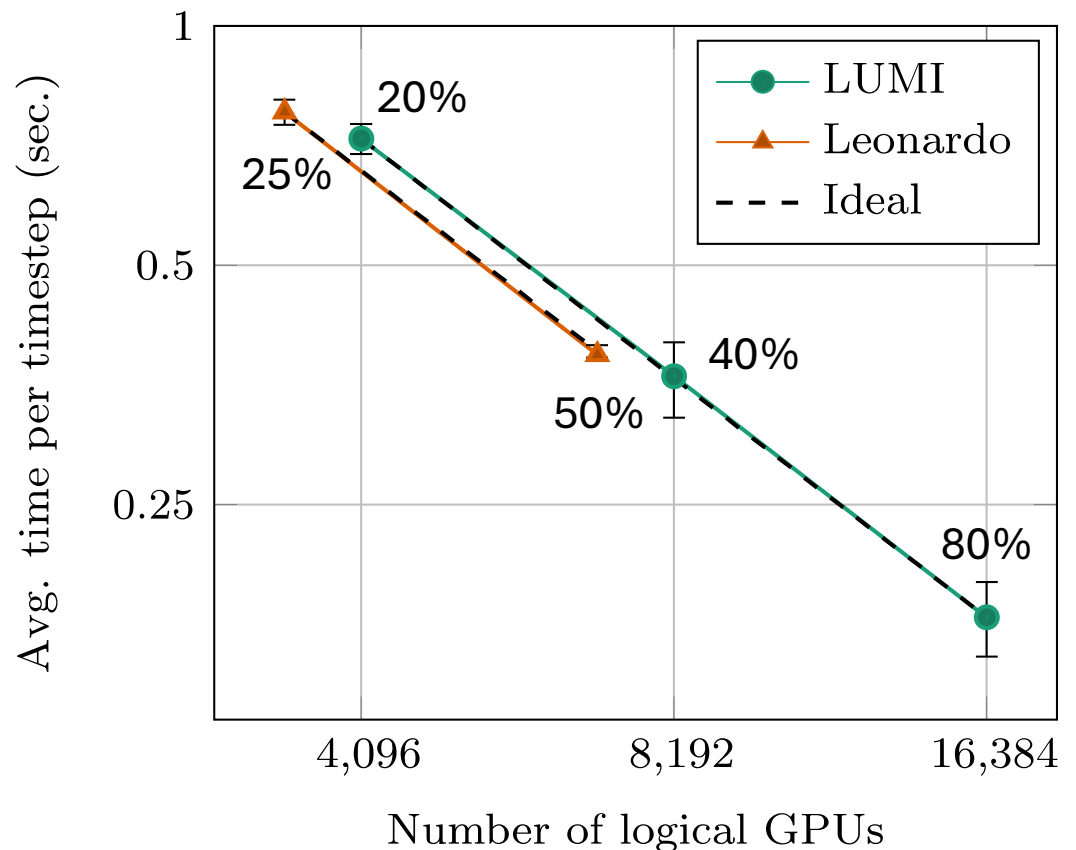
→ 37B unique grid points and more than  
**148B degrees of freedom**

N. Jansson et al., *Exploring the Ultimate Regime of Turbulent Rayleigh–Bénard Convection Through Unprecedented Spectral-Element Simulations*, SC '23: Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis, 2023.



Huusko et al. 2025 (JAMES)

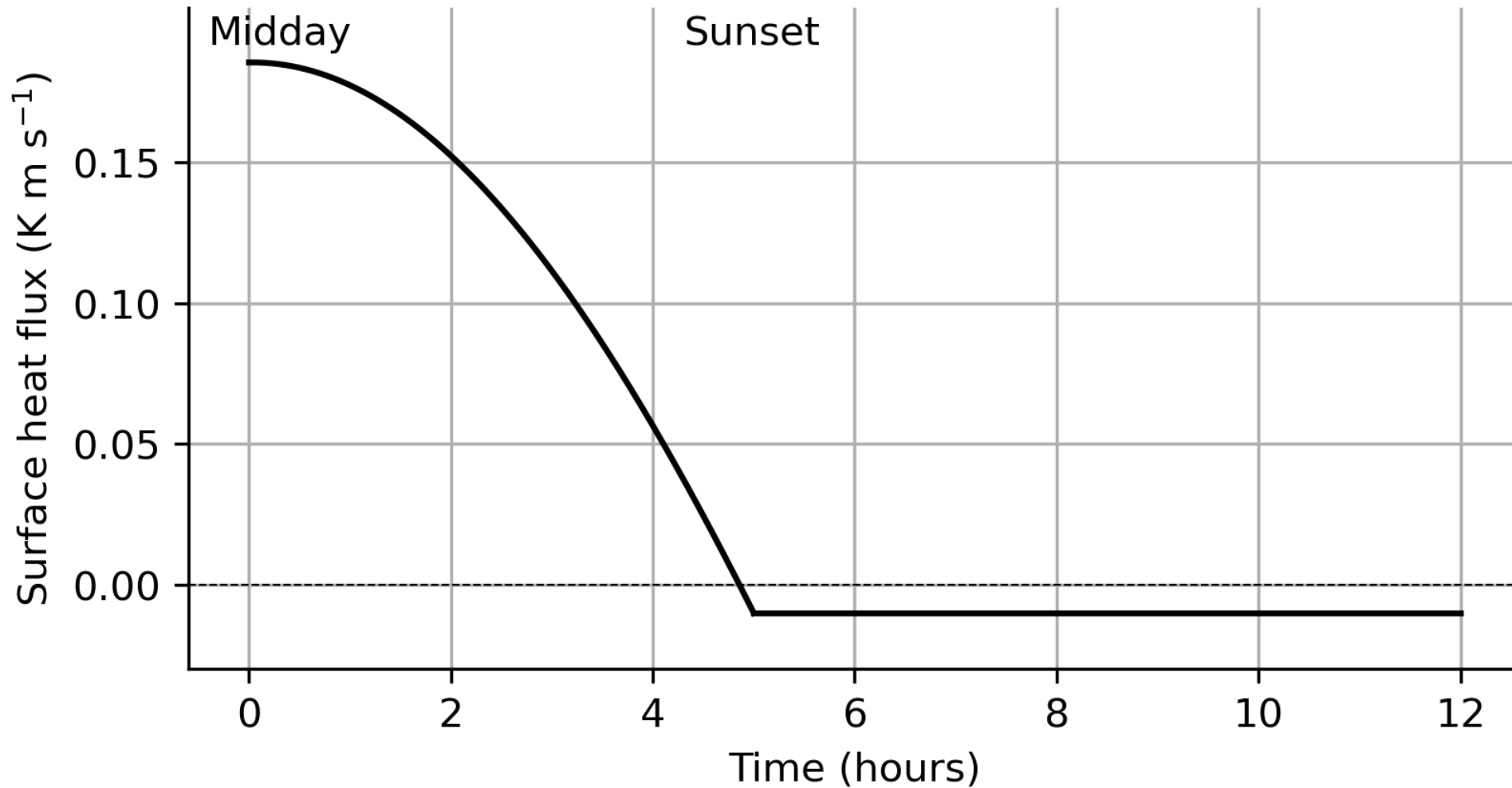
RBC  $Ra 10^{15}$ , 108M el., 7th order poly.



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# Simulating the evening transition





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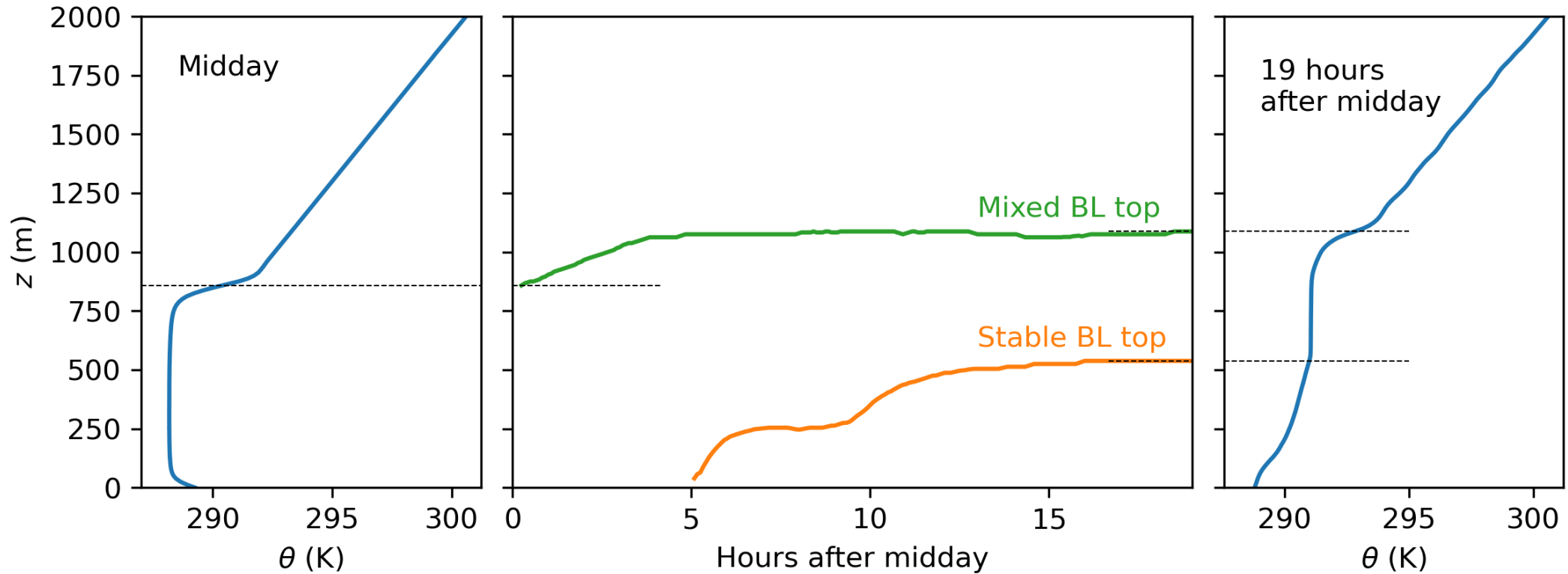
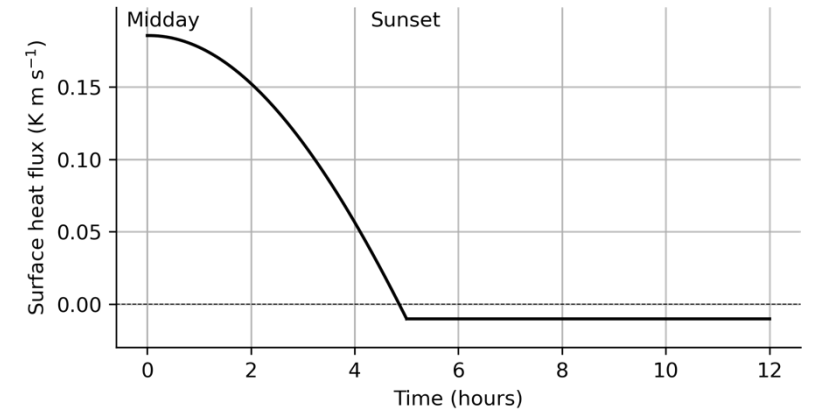
$$L_x = L_y = 5000 \text{ m}$$

$$L_z = 2000 \text{ m}$$

$$\Delta x = \Delta y \approx 20 \text{ m}$$

$$\Delta z \approx 8 \text{ m}$$

$$N_x = N_y = N_z = 256$$



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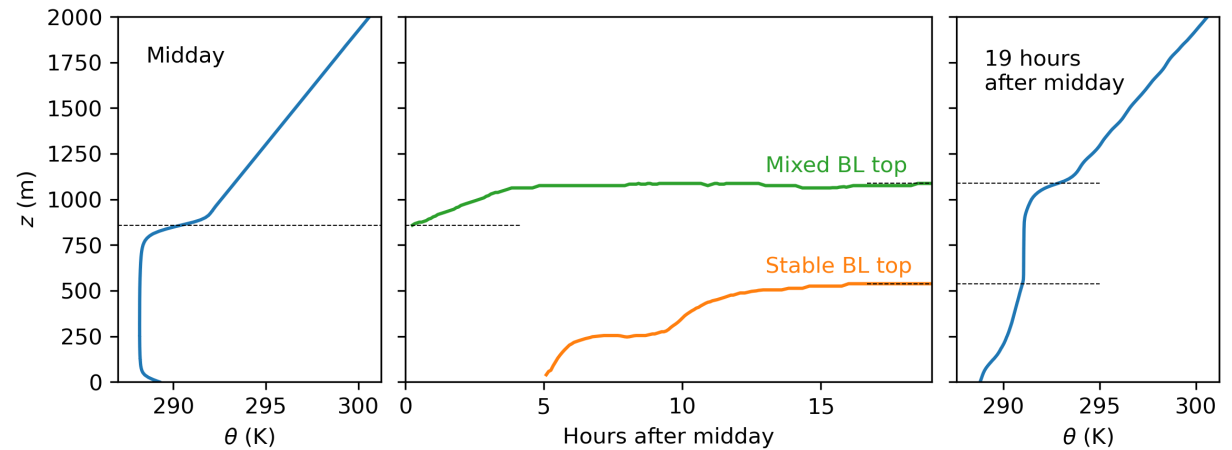
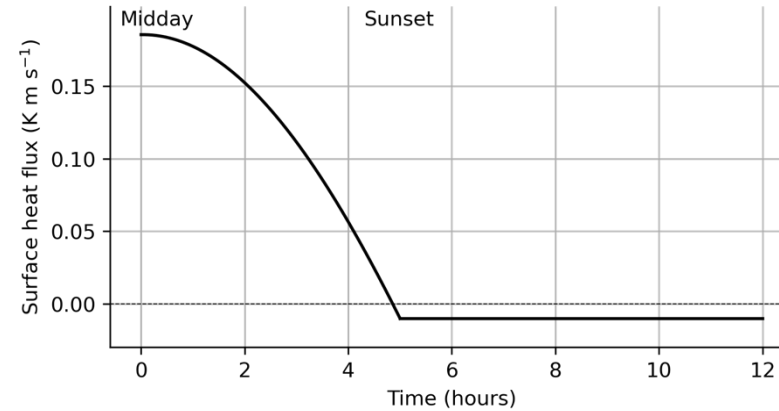
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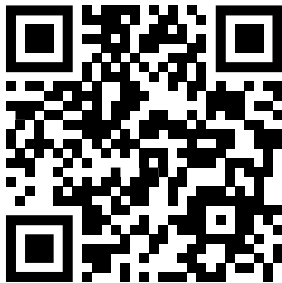
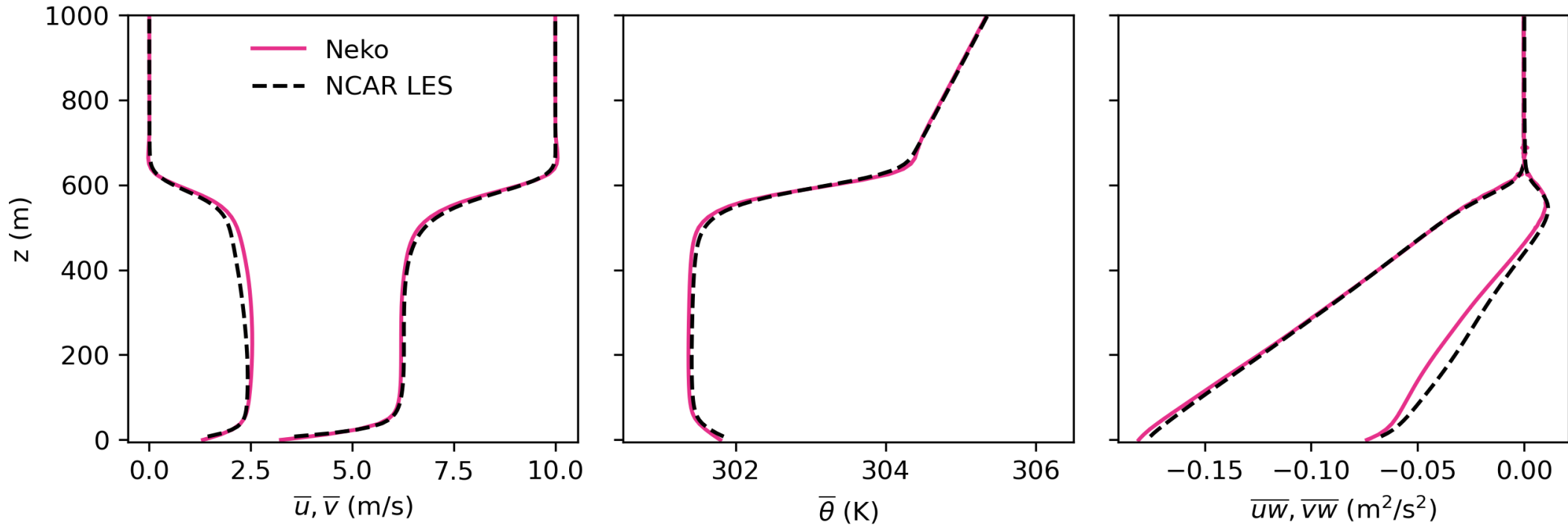


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Thank you!





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