

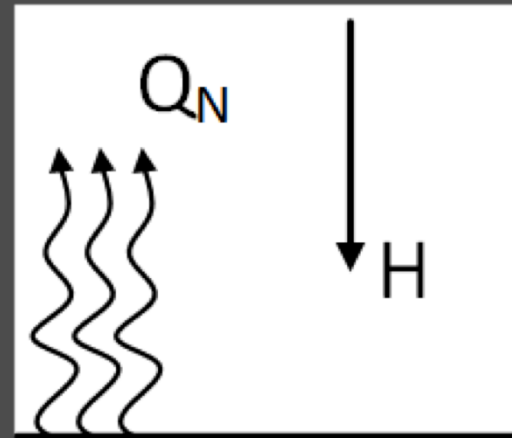
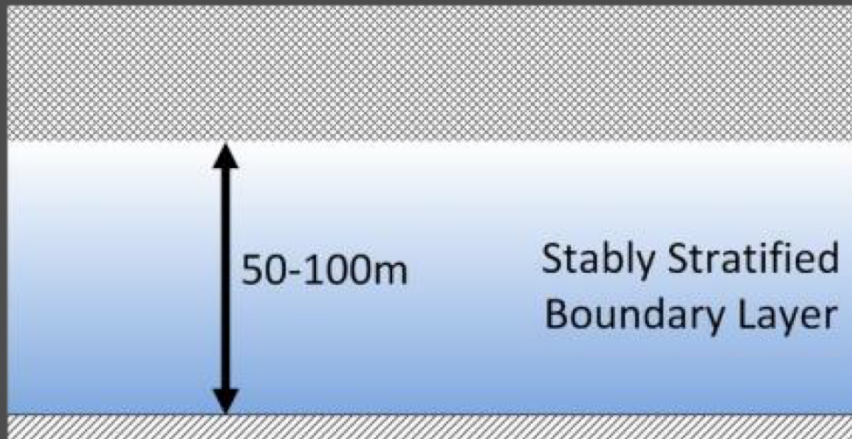
COLLAPSE OF TURBULENCE IN THE STABLE BOUNDARY LAYER

I. van Hooijdonk, A. Moene, H. Clercx ,
M. Scheffer and B. van de Wiel
09-02-2016

A cold night

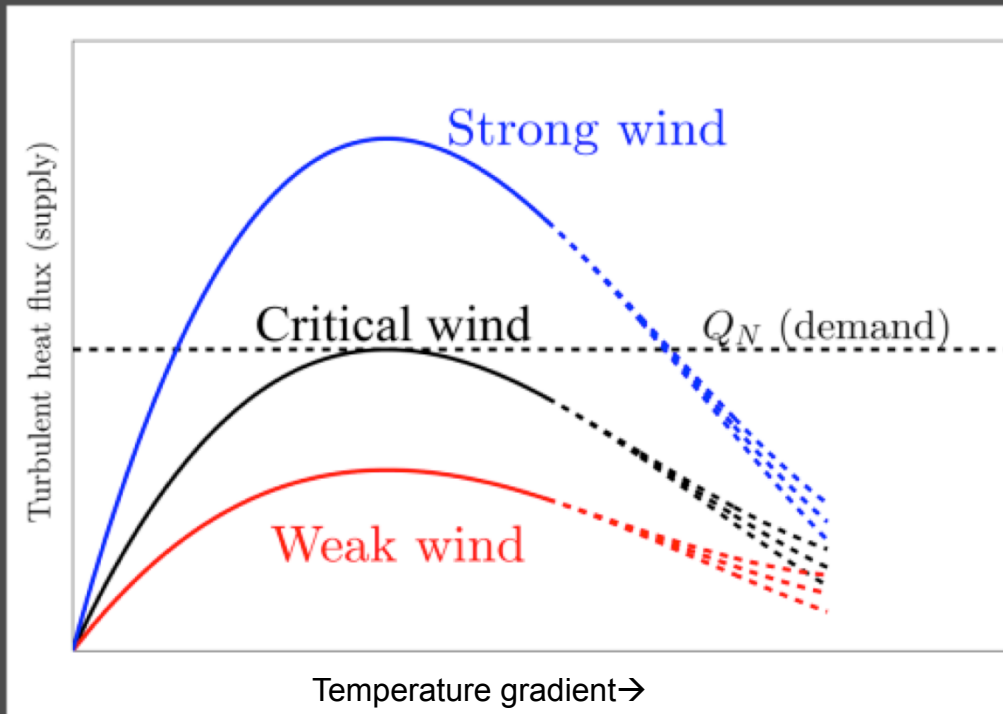


Stable Boundary Layer



$$c_v \frac{\partial T_{surface}}{\partial t} = -Q_N + H$$

Surface energy balance



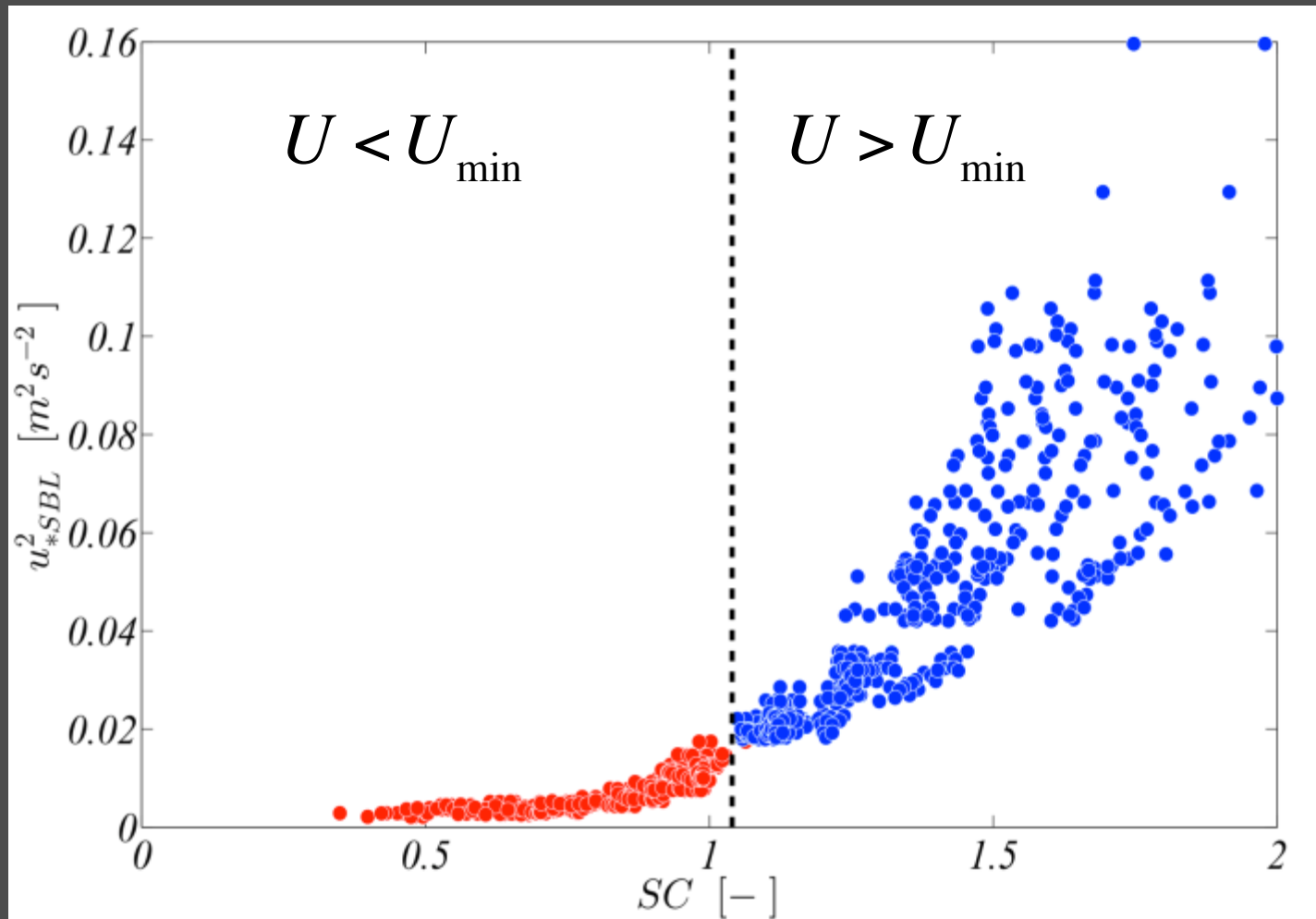
$$SC \sim \frac{U}{U_{\min}}$$

van Hooijdonk et al. (2015)

$$U_{\min}(z) = \left(\frac{27}{4} \frac{\alpha g}{\theta_0 \kappa^2} \frac{Q_N}{\rho c_p} z \cdot \ln(z / z_0)^2 \right)^{1/3}$$

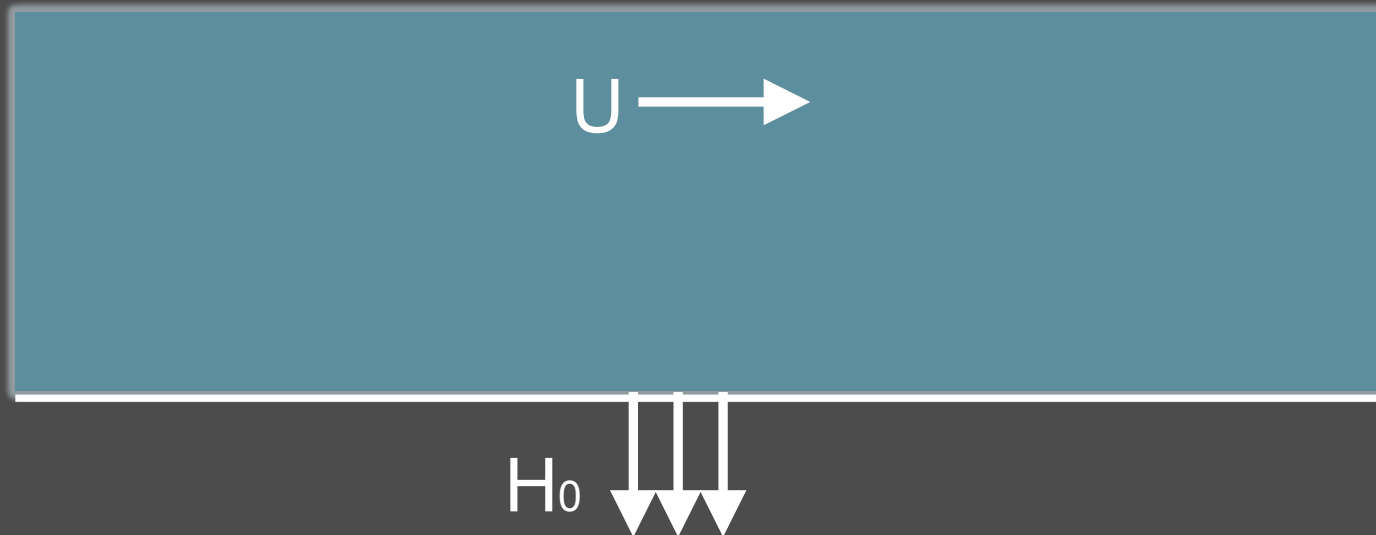
van de Wiel et al. (2012a)

Observations



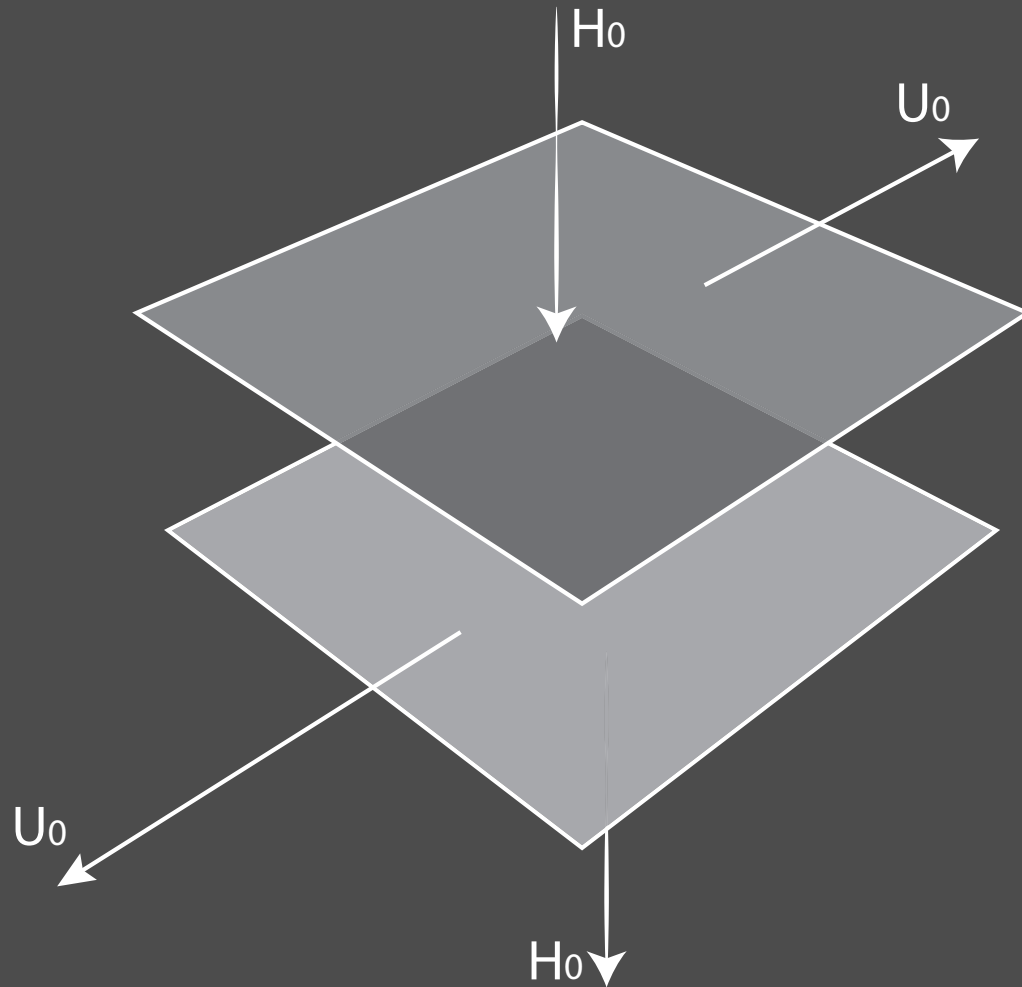
Two regimes

- Strong wind / Weak cooling → Turbulent, warm nights
- Weak wind / strong cooling → Quiet, cold nights



- $U_{\min} \sim H_0^{1/3}$

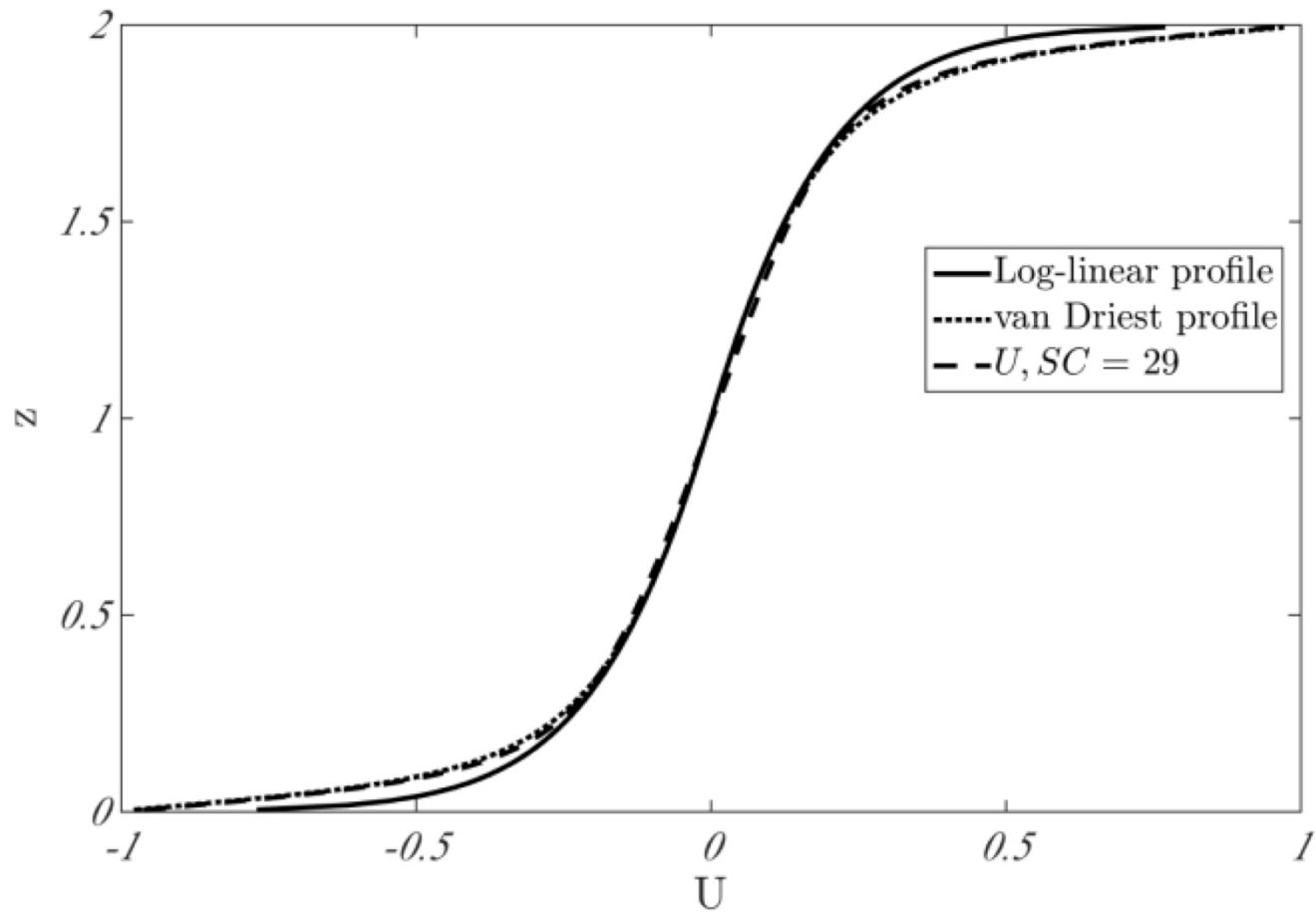
Setup



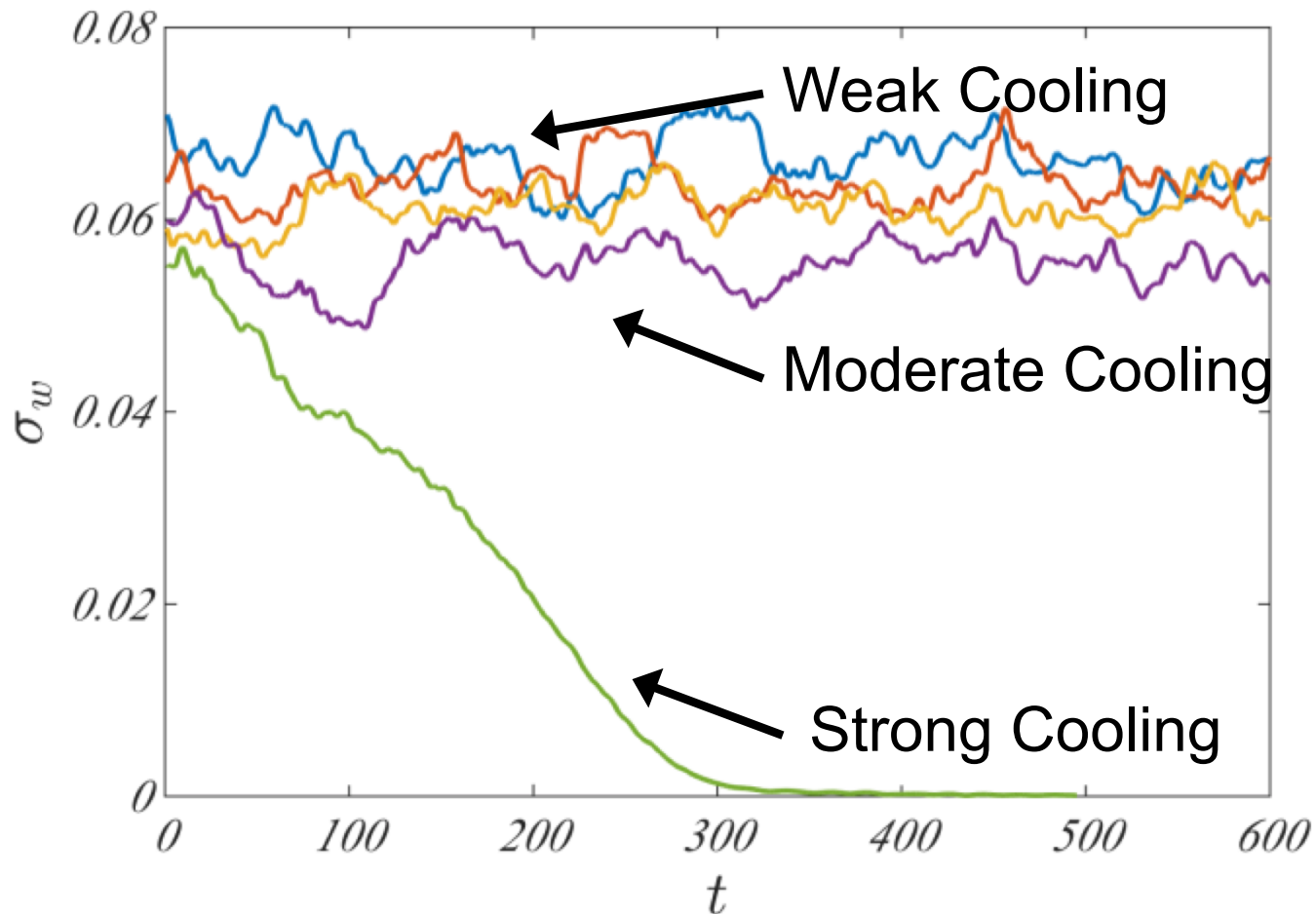
Direct numerical simulation

- Directly solves Navier-Stokes equations
- No closure required
- Limited Reynolds number

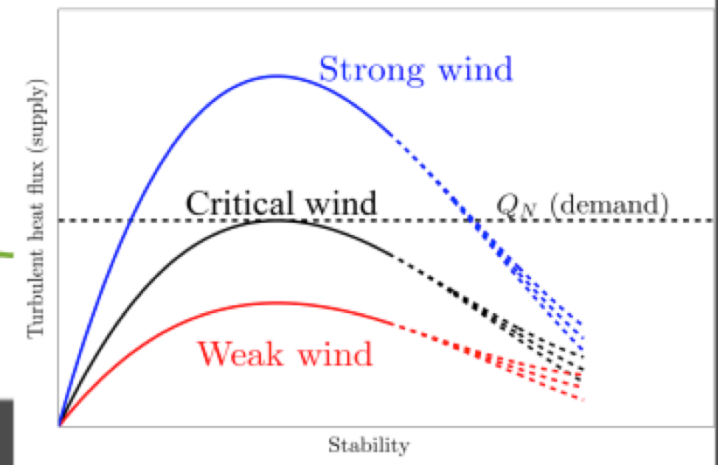
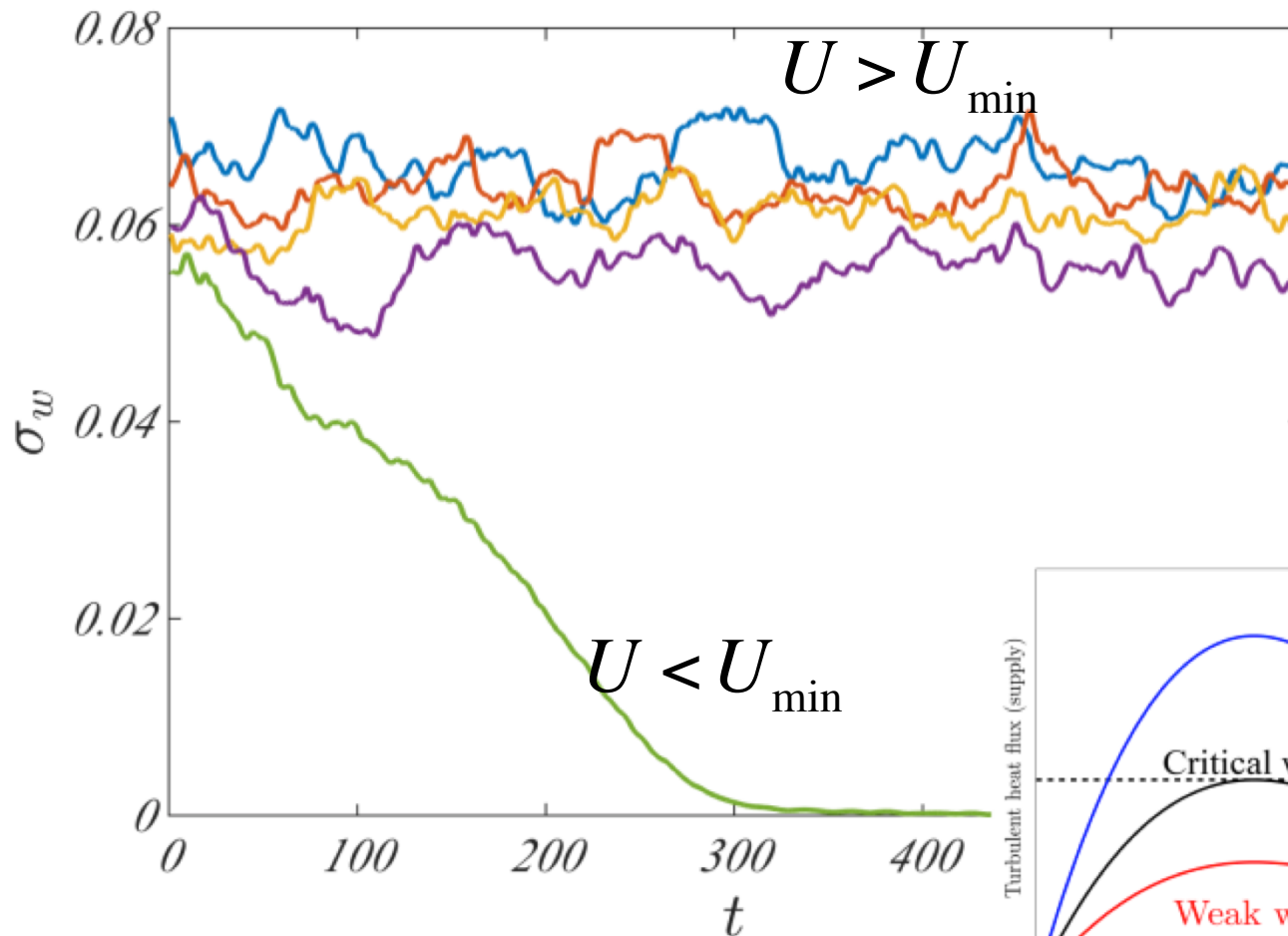
Validation



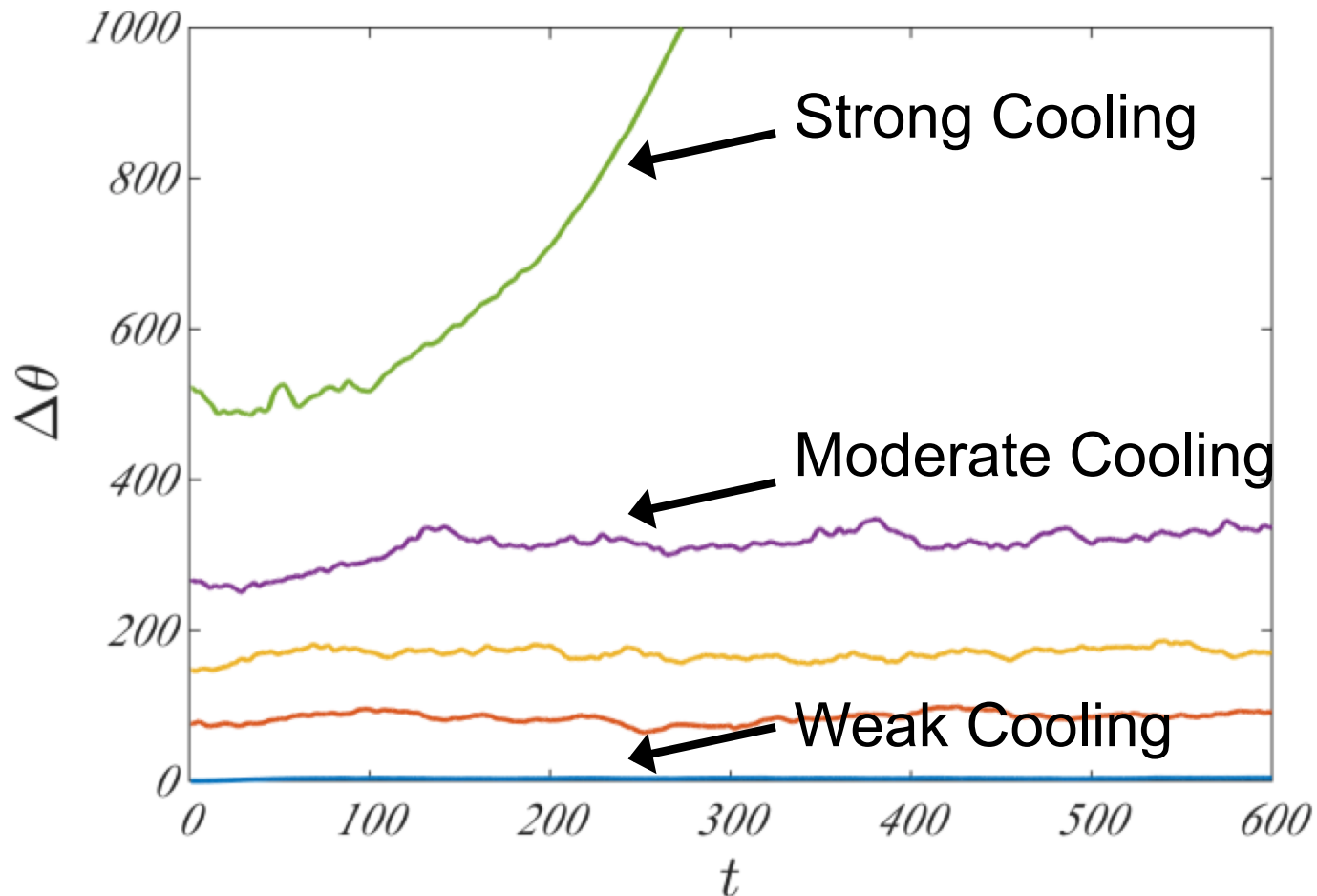
Turbulence



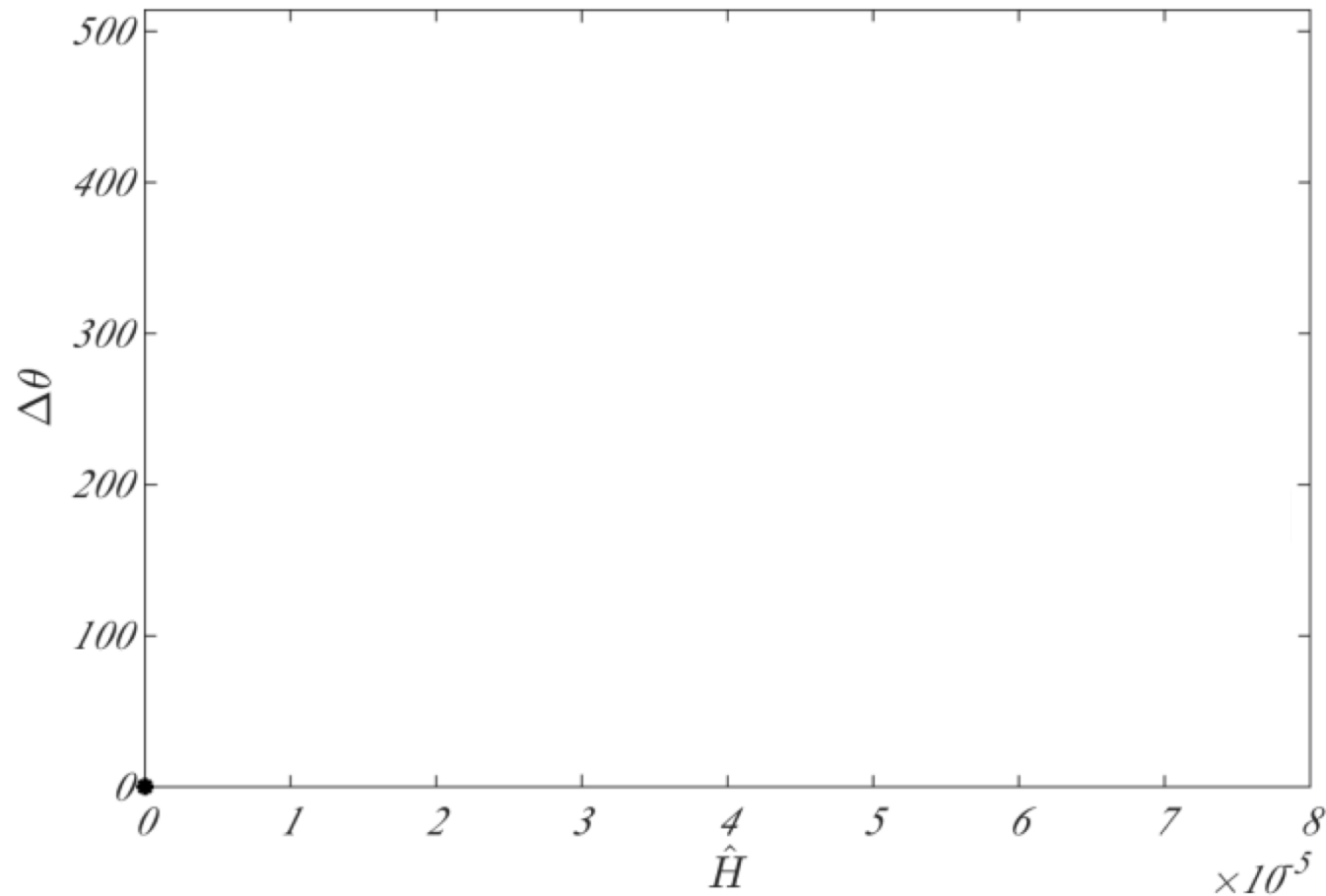
Turbulence



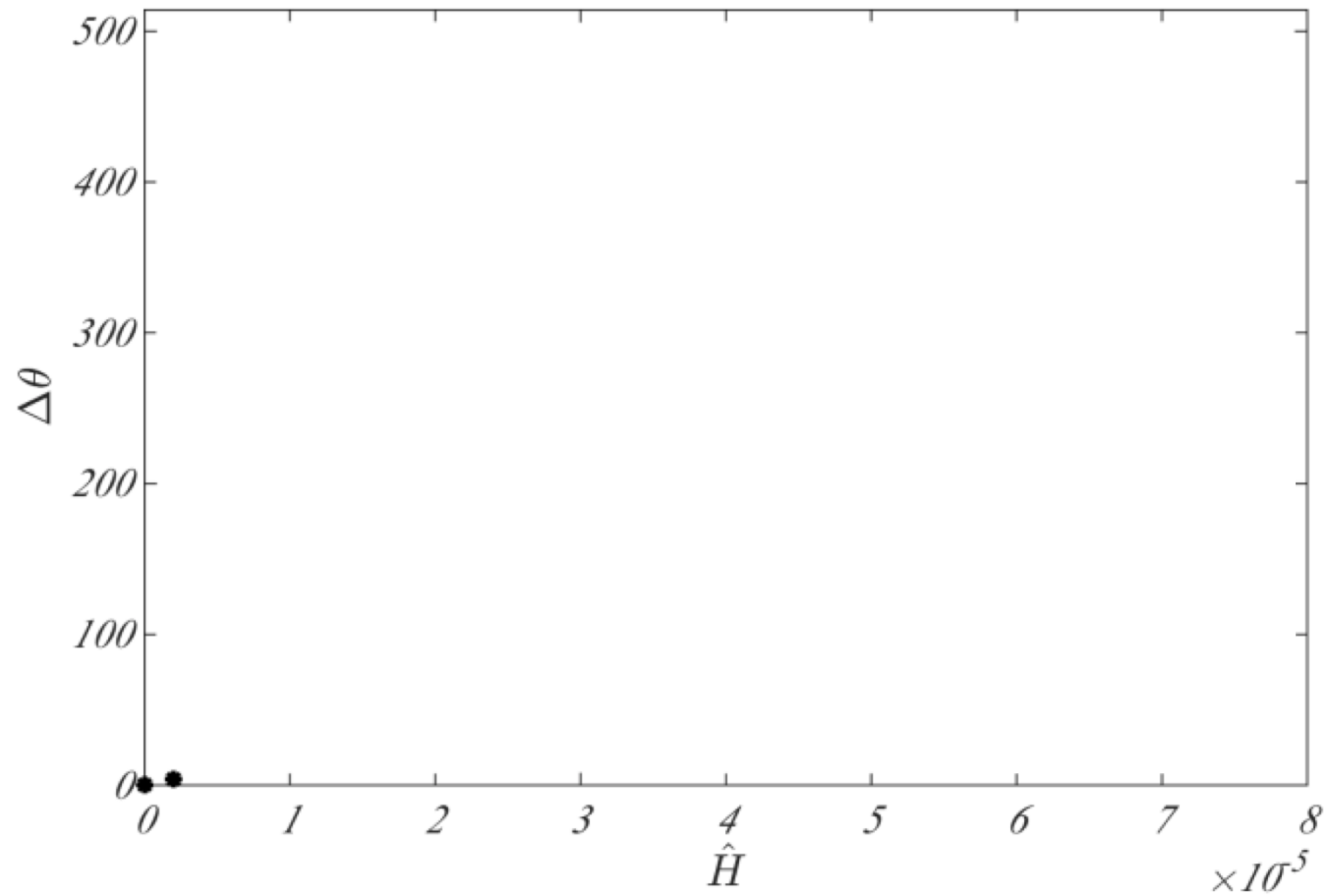
Temperature



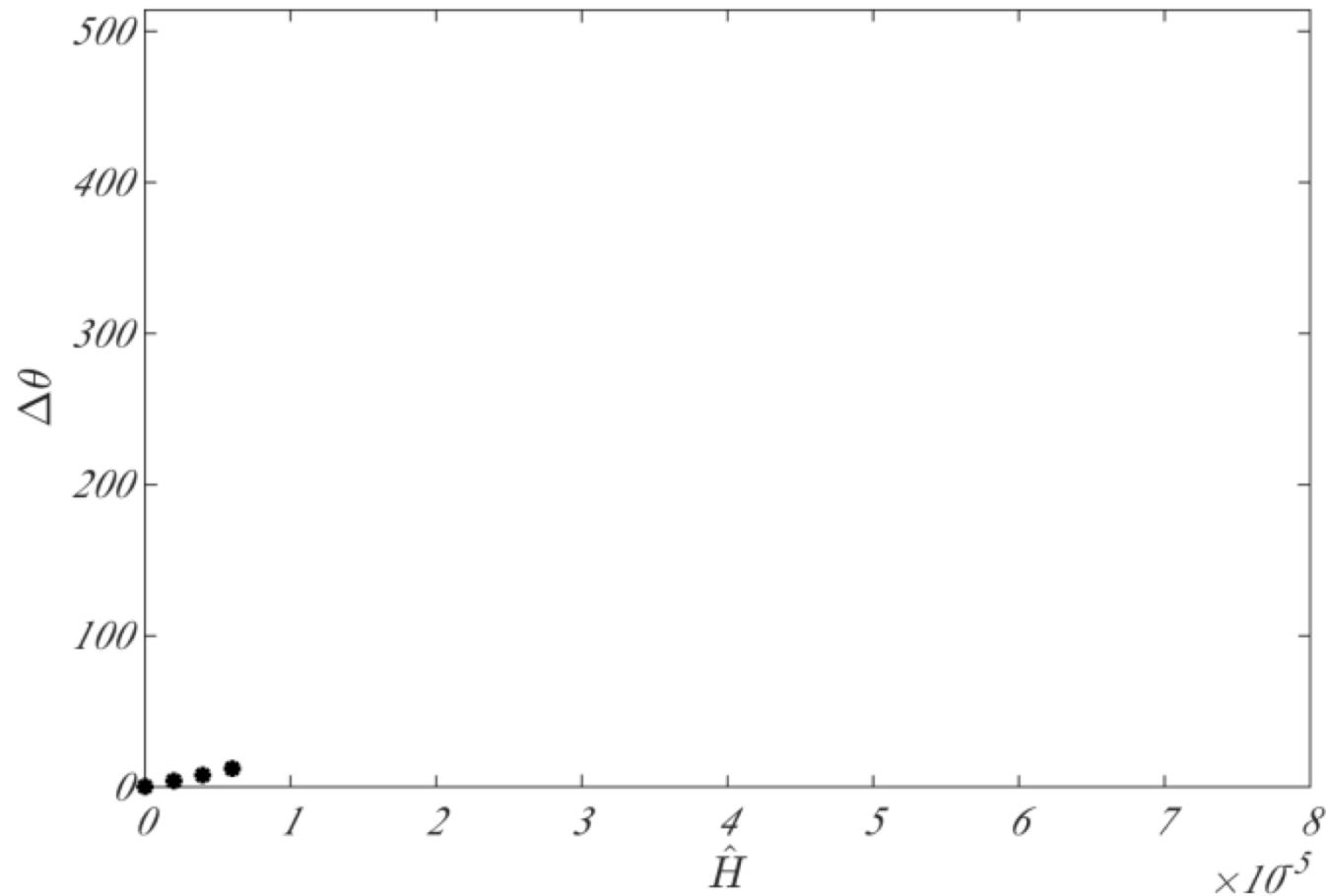
Steady state



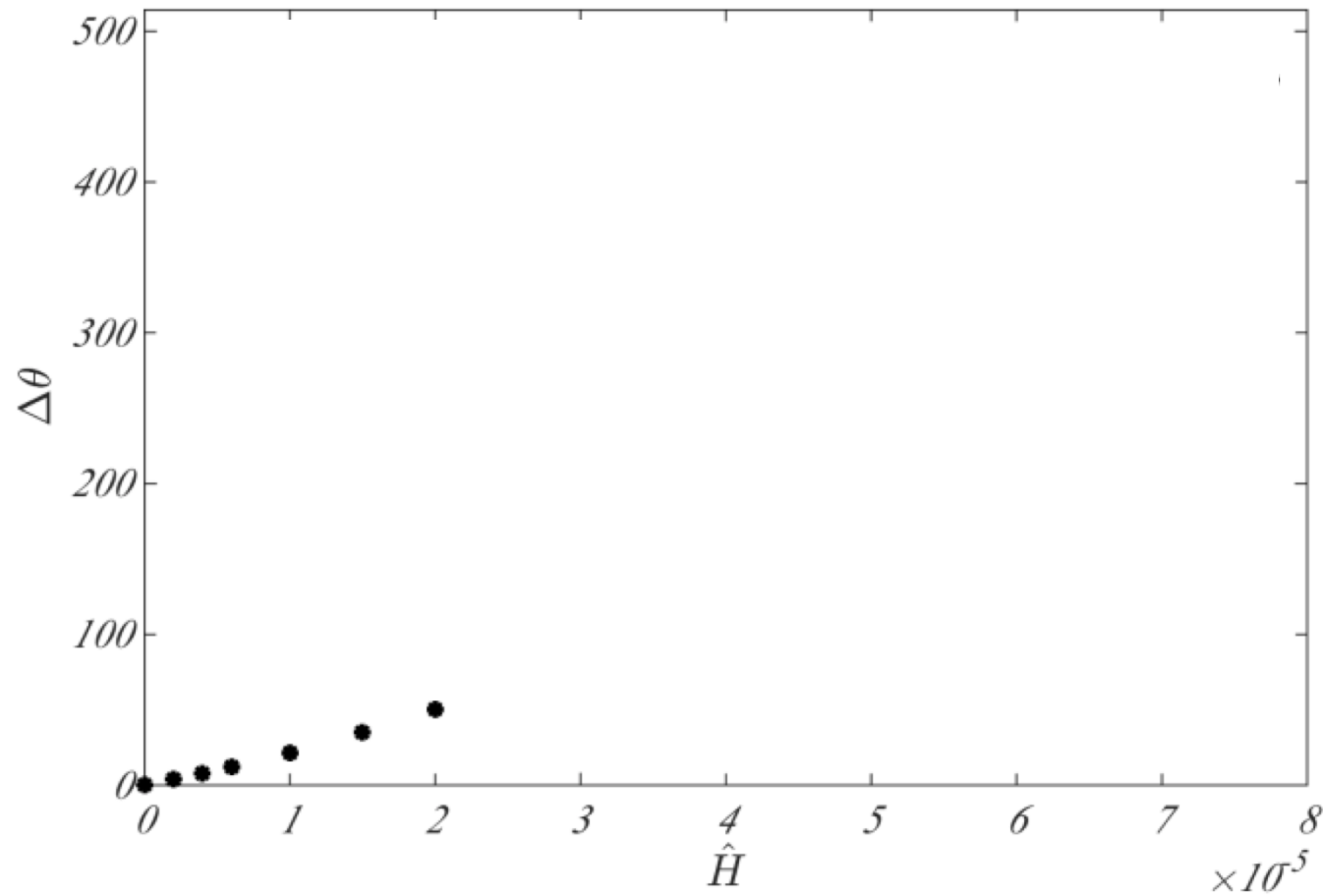
Steady state



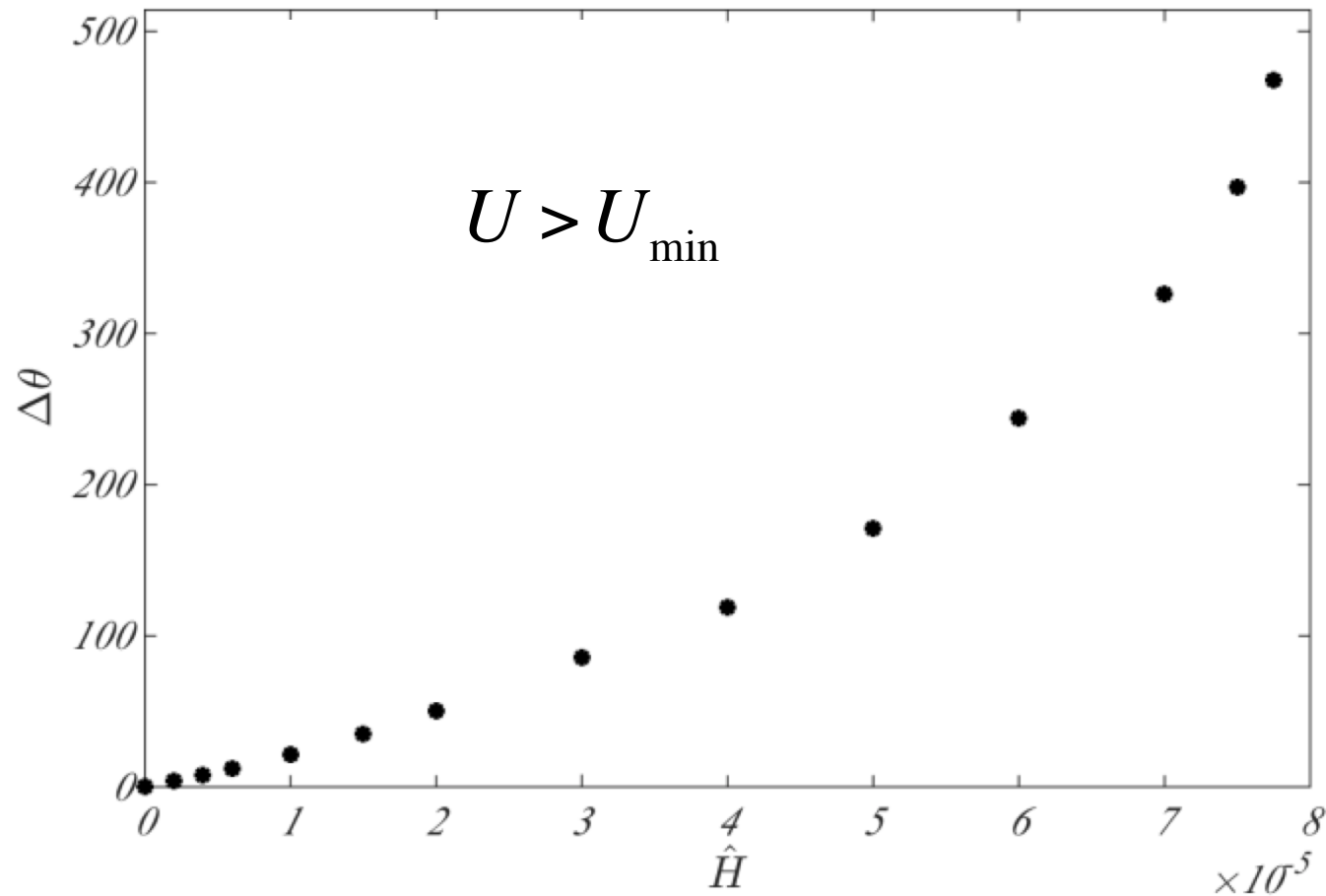
Steady state



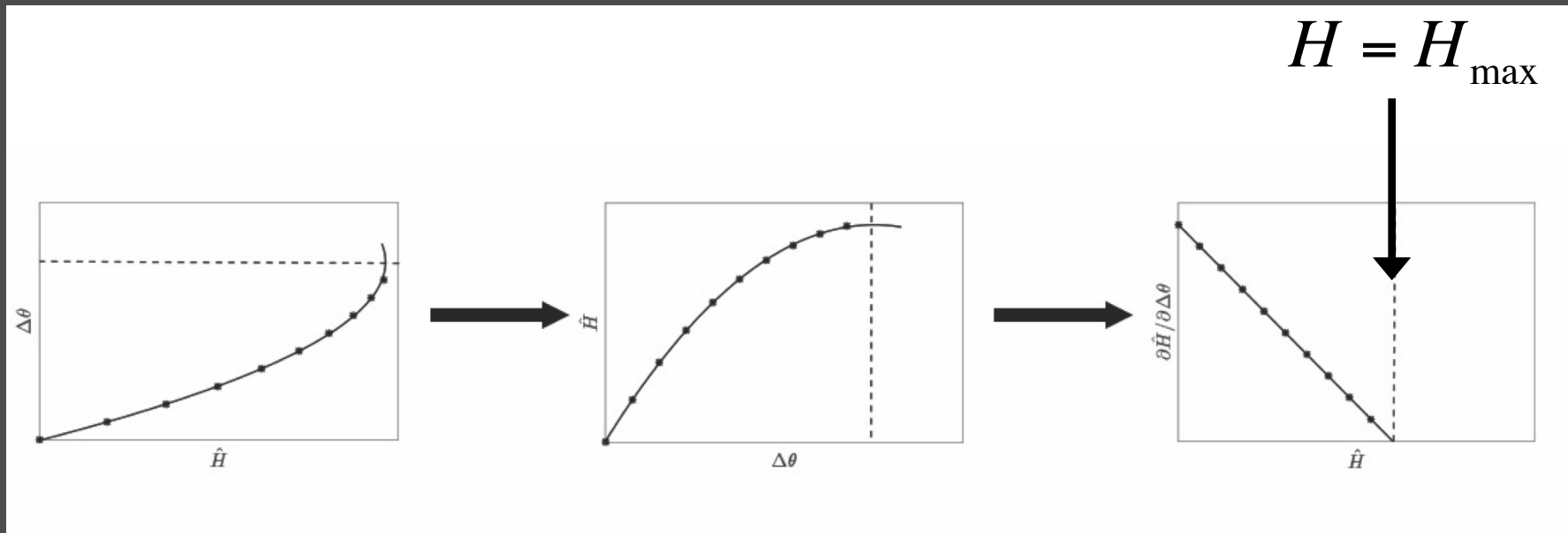
Steady state



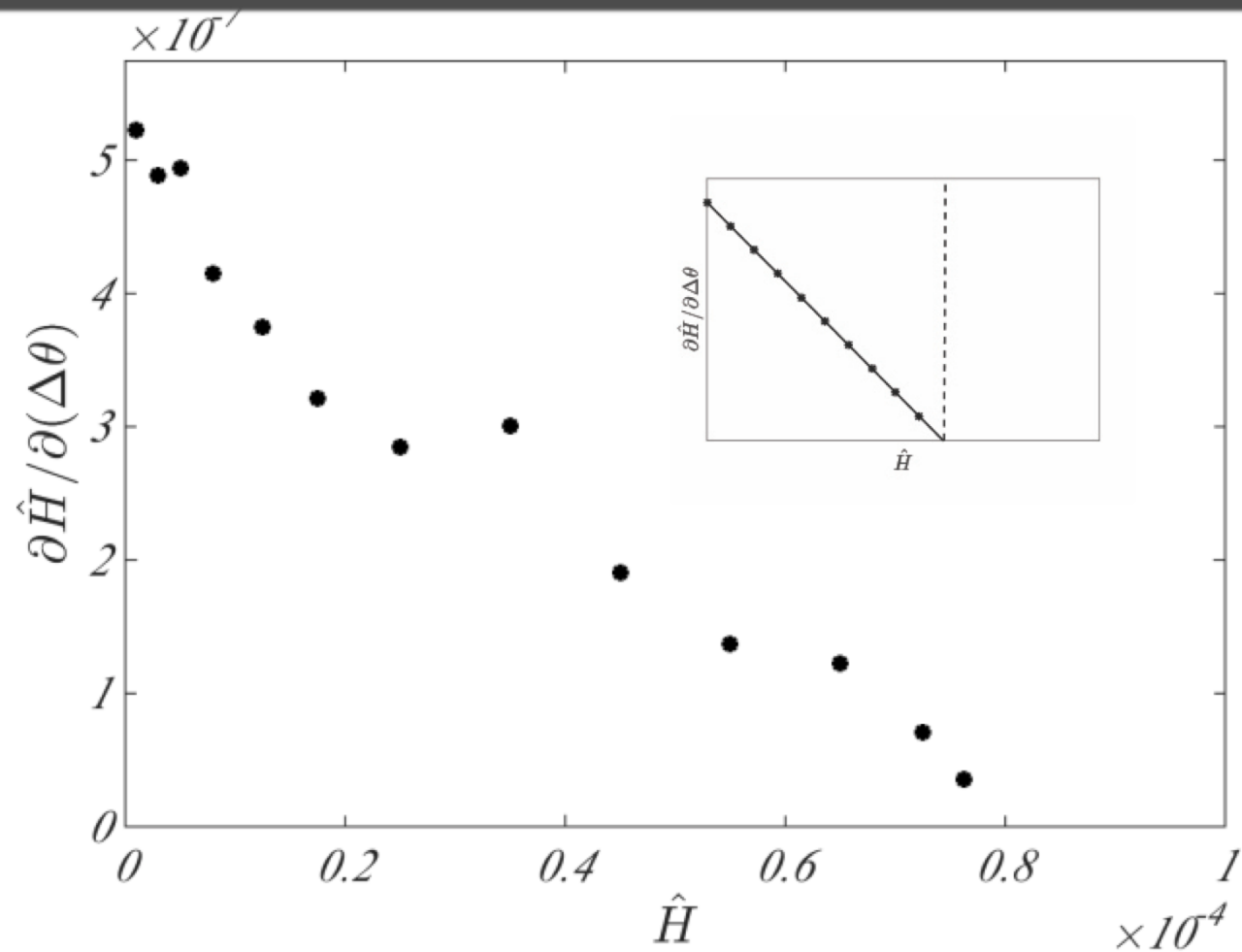
Steady state



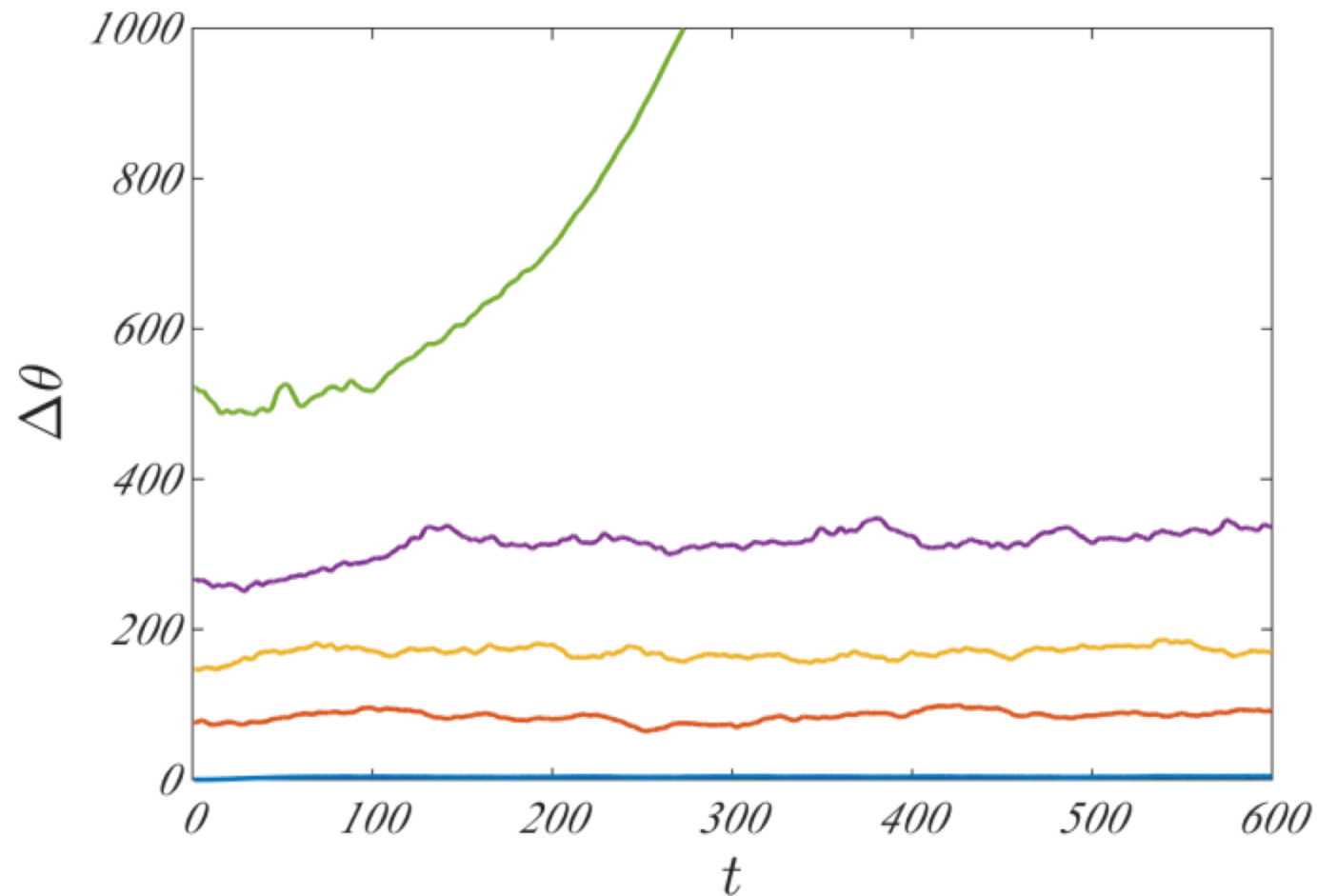
Maximum Sustainable Heat Flux



Validation



Temporal evolution



Conclusions

- Consistency of results: 3D models, 1D model, field observations, analytical results
- Turbulent flow fields contain information on transition
- Transition point can be estimated from this information

Thank you for your attention

Research:



Funding:



Further reference:

DNS: Donda et al. (2015) Q. J. R. Met. Soc.,
Observations: van Hooijdonk et al. (2015), J. Atmos. Sci., Vol. **72**,
Current results: van Hooijdonk et al. (2016), BLM, submitted